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A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

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This Association has six regular meetings each year, all of which, except the annual convention in September, are held at Boston.

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PRINCIPLES OF RATE-MAKING.

(As illustrated by recent Water-Works cases.)

BY WILLIAM M. WHERRY.*

[*Read September 15, 1926.*]

I propose in this paper to review briefly the questions raised and disposed of in water-works cases reported since January 1, 1925, dealing with rate-making, so as to give you a picture of the points which are at issue, and to consider how far we have progressed in the development of scientific principles and their application to the problems of the water-works industry.

The general principles of rate-making are now pretty definitely settled and are common to all classes of utilities. There are still, however, many disputed points over the application of the principles and methods of proof. There are problems common to all utilities, and problems peculiar to water works. A rate case is still an intricate and difficult proceeding and requires most careful preparation and presentation.

A few statistics will bring this out more clearly.

Since January 1, 1925, there have been approximately 1 300 reported cases involving public utilities. These cases have arisen from all parts of the country. Of this number about one-third are cases in courts, either by direct appeal or injunctions, or, in a few instances, original proceedings. The balance are before commissions.

During this period we find seventeen cases involving valuation of water utilities, of which five cases, or 29 per cent., were taken to the courts. These five cases were not from one jurisdiction, but from New Jersey, Virginia, Indiana, Missouri, and Idaho. In one instance, namely, the Roanoke case, the matter went to court twice, on two separate appeals, and during this period it came back a third time to the Commission for revision of their original findings.

The proportion of appeals is a fair measure of the difficulty of securing proper solution of the problems and a correct and fair application of the

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principles established by the courts. Even this is not the full measure of the importance of the courts in rate-making. Many of the cases decided during 1925 and 1926 by the commissions, although not directly appealed, involved points which had been taken to the courts in other proceedings.

It is clear from this that a rate proceeding must be treated as a case in court, and prepared with the same skill and diligence, and presented with the same thoroughness before the commissions, as if an appeal were to be taken in each instance.

I.

As early as *Smyth* v. *Ames*, 169 U. S., 466 (1897), — and that was thirty years ago, — the fundamental principle which underlies all rate-making was laid down by the Supreme Court of the United States. In that case it was held that a company was entitled, through its rates, to earn not only its operating costs and taxes, but a fair return on the fair present value of the property devoted to the public use. That formula has been repeated thousands of times. It is simple and clear, and one would suppose that there could be little difficulty in applying it; and yet, as late as 1923, we find it challenged in the very court in which it originated, and an attempt made to substitute prudent investment for present value as a rate base. This has definitely failed so far as the courts are concerned, and the failure is now being reflected in the decisions of the commissions, where valuation is involved. The difficulty with this formula has not, however, been so much in obtaining a recognition of the principle, as in the methods of proving the different elements, and, in addition to these, the reconciliation of this principle with another fundamental and elementary principle in rate-making.

The other principle is that the rates are the compensation for service and must not exceed the value of the service rendered. (*Board of Public Utility Commissioners* v. *New York Telephone Co.*, Sup. Ct. Adv. Op., May 1, 1926, p. 436.)

Now these two principles, namely, that the company is entitled to a fair return on the fair value of its property, and that the customers are not to pay more than the fair value of the service rendered to them, come in conflict in fewer cases than one would perhaps at first expect. In a great majority of the cases the service is clearly worth all that it costs, including a fair return on the fair value of the property. In rare instances it may be worth less. In the latter cases, the difficulties of proof as to the real value of service are quite as great as those difficulties of proof which have been overcome in establishing the fair value of a going concern without capitalizing its earnings.

During the period under review there have been two or three cases which bring out this conflict in rather important aspects.

A corollary of the principle laid down in *Smyth* v. *Ames*, namely, that the company is entitled to a rate which will yield it a fair return on its

property, is the proposition that the right to fix the rate belongs to the company so long as the rate which it fixes is reasonable. The State has no power under our Constitution, nor any right to interfere with a rate established by the company, unless that rate is unreasonable; that is, either unfair or excessive. This corollary is recognized by the courts, although there are not many cases which explicitly state it. One such case arose in 1925, where the principle was directly involved and explicitly expounded by the New York Supreme Court. (*Follett* v. *Water Works Co. of Seneca Falls*, New York, 123 Misc. 825.)

From this proposition it would follow that if the State does interfere with the rate fixed by the company and compel the company to charge a lower rate than that which it had established, the company is entitled to make up the enforced deficits out of future earnings. This was established in the Hackensack Water Company case. (*Hackensack Water Company* v. *Board*, 96 N. J. Law, 184.)

It rests squarely on the principle that the State has no power to interfere with the rate of the company which is fair, just, and reasonable, and when it does, the company has a right to amortize and make up the losses which it has suffered through the illegal act of the State in compelling it to charge a rate so low as to be unfair and unreasonable.

But it is just at this point that the other principle comes into play, namely, that the company cannot charge in its rates more than the fair value of the service. It is clear that present customers are not entitled to pay less than the fair value of their service because some other customers in the past may have paid more than such value. On the contrary, it is equally clear that present customers ought not to be compelled to pay more than the fair value of their services because some other customer has paid less than such value.

In the Telephone case, above referred to, the Supreme Court of the United States for the first time clearly and explicitly decided the first of these propositions not by *obiter dictum*, not by inference, but by direct decision. The court held that excessive earnings in the past, even if clearly established, would be no reason for lower rates at the present.

The contrary of this, namely, that deficits caused by low rates in the past are not to be made up out of present rates, was decided by the same court in the Galveston Electric Company case. (*Galveston Electric Company* v. *Galveston*, 258 U. S. 388, 396.)

The commissions follow this rule very generally, and during 1925 and 1926 it was followed by the Missouri Commission in *Capital City Water Company* (P. U. R. 1925-D, 41), and in Virginia, in the famous Roanoke Water Company case. (*Commonwealth* v. *Roanoke Water Company*, Virginia, P. U. R. 1925–B, 303.)

In that case, however, the Commission, while refusing to allow amortization of losses due to the company's own fault, did fix a rate so as to permit of an amortization of losses caused by the Commission's exclusion from the

rate base of items which the courts of Virginia held must be included. Thus, in a single case we find a clear application of the general rule and its exception.

The conflict of these two principles governing rate-making is most frequently illustrated in cases where the service of the company is deficient. There were two interesting cases involving this question in the period under discussion.

In one case the Connecticut Commission made a lower rate for fire-protection service than would have been scientifically justified, because of low pressures and the proximity of another source of water for fire protection — and in fact a rate that was too low to yield a fair return on the fair value of the property. (*Mystic Valley Water Company*, P. U. R. 1925-D, 404.)

A similar question was put up to the New Jersey Commission in the *Middlesex Water Company* case (P. U. R. 1925-A, 1), and similar action taken by the Commission; but the Federal Court reversed the Commission's order and applied the rule first established in the Elizabethtown Water Company case, in the same jurisdiction. (*Elizabethtown Water Company* v. *Board*, 119 Atl., 284; 123 Atl., 358.)

In the Middlesex case, the Commission found what it would consider a rate which would give the Company a fair return on the fair value of its property, and directed that because of inadequacy of service the Company should charge 10 per cent. less than this so-called fair rate until the service was made adequate. (P. U. R. 1925-A, 1.) The court held that the cause of the poor service was the inadequate rates, and that the Company should not be penalized for defects in service which were beyond its control to remedy, and not due to its fault. (*Middlesex Water Company* v. *Board of Public Utility Commissioners*, 10 Fed. (2nd) 519.)

The Federal Court cited the Elizabethtown case, and in that case the Court of Appeals adopted the opinion below, in which the following occurred:

"The policy of the law is and should be to aid utilities to properly function and to render adequate service to the public, by permitting rates to be charged for the service rendered which would yield an adequate return upon the capital invested, maintain the property and attract capital. The policy should never be one of destruction. *O'Brien* v. *Public Utility Board*, 92 N. J. Law, 44. A starved utility is in no better position to render proper service than a starved horse or a motor car without fuel."

It should be noted that in neither the Mystic Water case nor the Middlesex case was there any proof that the service was worth less than its full cost, including a fair return on the fair value of the property. What the commissions did was to inflict a penalty on the Company for defects in service by denying it a fair rate for the service rendered.

It is always most difficult to establish the fair value of service by any other criterion than the cost to render it, including the cost to reproduce

the plant necessary and requisite for the service. In a few instances this has been attempted, but in no case during this period.

In the Mystic Water Company case, above referred to, however, it will be noted that there was another available water supply, and that this was a factor which the Commission considered in fixing a lower rate for fire service. In the Elizabethtown case, an attempt was made to measure the value of the service by setting up a hypothetical plant at a different place and estimating what service from such a plant would cost. This method of valuing the service was considered too remote and "speculative" in that case, following Judge Savage's rule in *Kennebec Water District Case*, 97 Maine, 185, p. 216.

In general, the service rendered by a water company is fully worth the cost, and really in excess thereof, because water is an absolute essential. Even though pressures may be below standard, and there may be a failure from time to time of complete service, the value of the service as a whole may easily exceed the cost of rendering it, including a fair return on the necessary plant. (*In re Shorewood*, P. U. R. 1925-B, 43 Wis.)

It is fair to say that in every case the basis of the rates must be the value of the plant.

One would suppose that a fair and honest effort to ascertain the fair present value of a plant would result in approximately an accurate result, and yet most of the litigation in rate cases has arisen over this question.

In *Smyth* v. *Ames*, the method which was used in valuing the property was an estimate of the cost to reproduce the plant new, less accrued depreciation. This was sustained by the court in that case as a recognized method of proof, although the court stated that other methods of proof, if they could be devised, might be equally important. Recent cases have clearly established that an estimate of cost to reproduce at current prices is the preferred method of proof today, where prices have so greatly increased over and above the original costs of existing utilities. Prices based on five or ten-year averages and split-appraisal methods have, in general, been disapproved by the courts. This progress, however, has not been made without constant recourse to the courts, and during the period under review we find the method disregarded and the commissions arriving at less than the fair value of the property in case after case.

In the Middlesex Water Company case, for instance, which has been referred to above, the Federal Court held that the Commission did not give sufficient weight to present prices in arriving at its valuation, and so low was the value which the Commission put on the plant itself as a whole that the court found the rate confiscatory without having to consider whether the Commission had properly treated accrued depreciation or water rights.

In *Boise Artesian Water Company* v. *Public Utility Commission*, 236 Pac. 525, the Idaho Supreme Court held that the Commission failed to give sufficient or proper consideration to reproduction cost in determining the value of the property for rate-making purposes.

We find the same error in the Roanoke Water Company case, *supra*. That case came back in 1925 to the Commission for revaluation, after having been twice before the courts. (119 S. E., Virginia, 268; 139 Va. 559; 124 S. E., 652.) The Commission had originally made a valuation based on reproduction at pre-war prices. This was overruled by the court. The Commission then applied a split inventory method of appraisal, that is, it took all items installed prior to 1914, and appraised them at their original cost, plus 40 per cent., and all additions since then at actual cost; and this method was approved in this particular case, although there are cases in other jurisdictions where it has been disapproved. (*Adirondack Power & Light Company* v. *Public Service Commission* (January, 1925), 211 App. Div. 272; *Peoples Gas & Electric Co.* v. *Public Service Commission* (January, 1925), 214 App. Div. 108).

The percentage method of appraisal has some advantages, however, because it does permit of using the capital accounts of the company as a basis, and thereby saves considerable time and expense. On the other hand, if there are any elements of value omitted from the books of the company, they would not appear in the rate base; and in some instance this may be a very serious omission. There are also many cases where costs cannot be accurately ascertained from the books, and to make an estimate of cost on pre-war prices would present more difficulties than to make an estimate of reproduction at present prices.

In *Carson Water Company*, P. U. R. 1925-A, 343, a former valuation made by the Commission was increased by the Commission to allow for an increase in the level of prices, but the Commission did not increase all elements in the same ratio, holding that water rights, going concern value, and real estate and working capital were of the same value in 1925 as in 1914. This conclusion of the Commission is certainly open to criticism, as in many jurisdictions water rights are very much more valuable today than they were twelve years ago; and the same thing is clearly true of real estate.

The Wisconsin Commission used the split inventory method in the *Ashland Water Company* case, P. U. R. 1925-A, 705, taking a ten-year average for all installations prior to 1916 and cost since. This seems to be in opposition to the current weight of authority.

The *Indianapolis Water Company* case, P. U. R. 1925-C, 431, came back to the Commission after the court held the earlier action of the Commission confiscatory, and in the new case the Commission took the value as fixed by the court as a rate base, which was somewhat less than a reproduction value on current prices.

Most of the cases which were reported from January 1, 1925, to 1926, show that during the early part of the period the commissions gave lower valuations than at the end. The tendency was to disregard current prices and fix a value at much less than reproduction new at current prices, but as soon as the cases began to come back to the commissions after court

review, this tendency on the part of the commissions diminished, and today a commission is more apt to follow the courts and appraise the property at its cost to reproduce at current prices.

There are exceptions, however.

For instance, in 1925 we find the New Jersey Commission valuing the Bound Brook Water Company on a cost of reproduction basis, on ten-year average prices, with a low working capital, and a low allowance for going value, although the engineers for the City and the Company had agreed on a value based on reproduction new at current prices (*Bound Brook Water Company*, 1925-B, 430), and the same Commission, in 1926, allows a valuation for a water company of about half-way between the original cost and the cost to reproduce at current prices, less depreciation. (*Washington Water Company*, New Jersey, P. U. R. 1926-C, 107.)

In *Capital City Water Company* the Missouri Commission in 1925 (P. U. R. 1925-D, p. 41) allowed something less than the cost of reproduction at current prices, and very much more than the actual investment, as a rate base.

In the San Jose Water Works case, the California Commission took original cost of a plant as a minimum to test whether the rates were too low or not. (*San Jose Water Works*, P. U. R. 1925-C, 370, 380.) This is an exceptional case and has no particular bearing on the principles or their application, except that it clearly illustrates that the function of the valuation is merely a test of the fairness of the rate; and to sustain a rate *proposed by the Company* it may not be necessary for the Company to include all elements of value in its rate base.

On the other hand, in the following cases the Commission practically gave full present value as measured by the cost to reproduce it at current prices:

Mystic Valley Water Company, Connecticut, P. U. R. 1925-D, 385;
School Directors of Highspire Borough v. *Highspire Water Supply Co.*, Pennsylvania, P. U. R. 1926-D, 80;
Water Works v. *Pacific Power & Light Company*, Washington, P. U. R. 1926-B, 837;
St. Joseph Water Company, Missouri Commission, P. U. R. 1926-B, 76.

To summarize: out of 17 cases, 12 were originally valued too low by the commissions; of these, 5 appealed to the courts and, after court proceedings, secured full valuation. Four other cases, decided by commissions subsequent to these court decisions, were correctly valued.

The above gives a summary of the cases dealing with the question of valuation as a whole.

Particular elements of value still give rise to dispute and difficulty. No one has been able, for instance, to advance any logical reason why, in an estimate of cost to reproduce an existing plant, the increase in value due to paving over of its mains, should be disallowed. It is obvious that a main laid under a paved street is worth more than a main laid in a country

road. We have here all of those elements which make the unearned increment of real property so large in centers of great growth in population. If the company is entitled to earn on the fair present value of its property, and every other owner of property is entitled to have his unearned increment protected, why should paving over of mains be excluded in valuations for rate-making? There is no logical answer, except the force of precedent. Yet courts have sustained commissions in excluding this element, and it is not now generally contended for.

During the period under review, one case involving this question arose, and paving over of mains was disallowed. (*Gernert* v. *Myerstown Water Co.*, Pennsylvania, P. U. R. 1925-B, 290.) No reason is given in this case. One reason that has been advanced for such disallowance is that the element of value was not paid for by the Company. For instance, in the same case of the Myerstown Water Company, the same Commission disallowed and did not include in the rate base service lines paid for by a customer. Of course, it is clear that if the real purpose of a rate case is to find the value of the service, and the present reproduction cost of securing a proper plant to render the service is an essential element in the value of the service, it makes no difference how this plant was acquired, whether by gift or by purchase; nor how its value was created, whether by management or good fortune. This is the rule as expounded by the Supreme Court in the Telephone Company case, already cited.

In that case, the question was raised with respect to property acquired out of earnings in the past. It was sought to exclude such property from the rate base, and the Supreme Court said:

"Customers pay for service, not for the property used to render it. Their payments are not contributions to depreciation or other operating expenses, or to capital of the Company. By paying bills for service, they do not acquire any interest, legal or equitable, in the property used for their convenience, or in the funds of the Company. Property paid for out of moneys received for service belongs to the Company just as does that purchased out of proceeds of its bonds and stock."

And again, the court in the same case said:

"It is enough if it is used to render the service. The customers are entitled to demand service and the Company must comply. The Company is entitled to just compensation, and to have the service the customers must pay it."

In all these rate cases we still have the difficult problem of structural overheads and going value. The problems of proof in relation to these two elements of value are common to all classes of utilities. In these cases it is very rare that one is able to prove that the company actually expended any definite sums which would be classified under either of these heads.

On principle, where one is dealing with value, it is not necessary to show that there were any actual costs so long as the element of value is clearly established. The methods of ascertaining it and proving its real worth are

less difficult in connection with structural overheads than with going value. Great confusion was introduced in this matter by the United States Supreme Court in the Des Moines case, where the court evidently confused going value with structural overheads; and in the Minnesota rate cases, where the court, in dealing with overheads on real estate, used language which indicated that it was of the opinion that actual expenditures must be shown for structural overheads in order to establish the validity of this element of value. This confusion has, however, been cleared up.

A more careful analysis and exposition has shown clearly the distinction between structural overheads and going value. It is now generally recognized that structural overheads are, in ordinary cases, a necessary and essential cost, just as bricks and mortar, and in the *Ohio Utilities Company* case, the Supreme Court of the United States laid down the principle that:

"In estimating what reasonably would be required for such purposes, proof of actual expenditures originally made, while it would be helpful, is not indispensable. . . . That such expenditures in a substantial amount would necessarily be made in reproducing the utility is clear; it is not suggested that the estimate of the engineers is excessive or unfairly made, and the rejection of the entire amount cannot be regarded as otherwise than arbitrary."

Ohio Utilities Company v. *Public Utilities Commission*, 267 U. S. 359.

This ruling and this statement of principle was made in connection with the omission of field overheads. The precedent was followed by the Supreme Court of Idaho during the period under review in this paper, in the case of *Boise Artesian Water Company* v. *Public Utilities Commission*, 236 Pac. 525.

When we come to going value, we have perhaps one of the most difficult elements to prove and establish.

It is generally recognized that this element exists in any earning property, but in case after case, companies fail to secure any proper allowance for it by reason of failure of proof. One common method of proof is to show what it actually would cost to establish a business and attach it to a plant, on the theory that this attached business is worth at least the amount which it costs to acquire it. Such a method of proof would be clearly within the principle above quoted from the Ohio Utilities Company case.

Other methods of proof have been developed and successfully applied in rate cases, in connection with other utilities, notably gas companies.

In the St. Joseph case, the Commission held that the Company's going value was not a function of the physical property. It increased all other elements of value made in a preceding valuation, but took going value at the same figure, on the ground that there was no proof that the business had increased. (*St. Joseph Water Company*, P. U. R. 1926-B, 76.) The Nevada Commission took a similar review in the Carson Water Company case, to which we have already adverted. In the Capital City Water

Company case, the Missouri Commission allowed no structural overheads on land (P. U. R. 1925-D, 41), and in the Mystic Water Company case, above cited, the Connecticut Commission allowed nothing for going value.

It may be said, in general, that, with a few exceptions, some allowance was made for structural overheads and going value in all the cases arising during this period, but that the methods of proof of the latter element in water cases can be very much improved.

There are two elements of value of peculiar importance to water companies, both of which require the same intensive study and constructive work as has been expended on going value and structural costs.

The first of these elements is assembly value of real estate. Water utilities having to acquire lands for reservoirs, by far-sighted effort, continued over a long period of time, — during which they are acquiring isolated pieces of property and connecting them up into a whole, — do create a real element of value in land, which is known as assembly value. Real estate experts who have had experience in such acquisitions know that this element may add from 50 per cent. to 100 per cent. to the value of the isolated plots of land. There are very few cases in the books where the companies have claimed this element of value or attempted to prove it. I recall offhand only one case, and that a telephone case, where it was allowed by a commission. During the period under review not one case is reported in which this element is treated or discussed.

The other element of value peculiar to water-works property is water rights. Ever since the San Joaquin case in the Supreme Court of the United States (*San Joaquin, etc., Canal & Irrigation Co.* v. *Stanislaus Co.* 233 U. S. 454), it is well established that companies are entitled to include in their rate base the value of their water rights and to earn on such value. Here also we have one of those intangible elements of value which is difficult to measure by cost or by any of the ordinary methods of valuation. In cases of purchase and sale it is easy to estimate the value of a water right by capitalizing the profits to be derived from its earnings. This was a favorite method of appraising all intangible elements of value, such as franchises and going-concern value. Study and analysis have shown a distinction between going-concern value and development cost; also between going-concern value and franchises. There is still, however, an overlapping of values when it comes to considering going-concern value and water rights, and this gives such difficulty in proof that very inadequate allowances are made in most water-works cases for water rights, even where it is attempted to value them separately.

In *Water Works* v. *Pacific Power & Light Company*, P. U. R. 1926-B, 837, the Washington Commission allowed the valuation for water rights of $189 000 out of a total valuation of over $5 000 000. The opinion states that the values found by various methods, testified to by the engineers, were all taken into consideration, and that the conclusion of the commission is a composite result, but the methods of valuing are not discussed or shown.

In the Washington Water Company case, *supra*, in New Jersey, water diversion rights were valued at about one-fifth of the valuation, but the method of valuation was not shown.

In the *San Jose* case (P. U. R. 1925-C, 370), there is an interesting discussion by the California Commission on the distinction between (1) riparian rights, and (2) rights of appropriation of water. The Commission stated that water-bearing land is worth more where the owner owns the right to divert for outside use against a lower riparian user; that the real estate appraisals of the land included the ordinary riparian rights, but not this additional value due to the right of appropriation, or right to divert for outside use. The Commission held that the right of appropriation was at least worth what it cost to acquire the diversion right as against lower users.

This principle has been applied in other water cases.

In the *School Directors of Highspire Borough* v. *Highspire Water Supply Company*, P. U. R. 1926-D, 80, the Pennsylvania Commission had before it valuation of water rights based on a comparison of costs from other sources. The water rights were valued by capitalizing the assumed saving in cost between furnishing water from the present source and the estimated cost of supplying water from some other source. This the Commission held was too fanciful and fallacious, disapproving it. It is similar to the method above referred to by which it was sought to prove value of the service in the Elizabethtown Water Company case, and it will be remembered that in that case also the court held the method too speculative. It was, however, successfully used as a method of valuing water rights in the *Roanoke Water Works* case, Virginia, P. U. R. 1925-B, p. 303.

It may be that some such method as this could be developed by further study. Certain it is, that at present there is no satisfactory method of proving the value of water rights. Occasionally, one is able to prove such rights by calling a witness who has actually acquired and sold water rights, and can give an opinion based on this experience, which, of course, would be entitled to due weight as that of an expert. The difficulty, however, is with the qualifications of the expert, as such purchases and sales are not frequent and occur at rare intervals, but would scarcely occur within proximate range of the water rights to be valued. Unless they are near in time and in location, they would be too speculative as proof of value.

The working capital of a water company in water cases, of course, must be included in the rate base, just as any other utility cases; but there is little discussion of proper allowance of working capital in any of the cases reported during the period under review.

The question of accrued depreciation is, of course, one of the most difficult problems in valuation and rate-making. For a long time property of the utilities was successfully undervalued by deducting from valuations large theoretical sums for accrued depreciation. The favored course was to use a straight-line method of accruing this depreciation. Perhaps the

most notable progress in rate matters during the last two years has been the decisions on accrued depreciation. We may say now that it is definitely established by the courts that all deductions for accrued depreciation must be based on actual proof, and that no form of life tables or arbitrary hypotheses or conjectures can be accepted as proof of the proper amount to be deducted; also that accounts and reserves are not the measure of the actual condition of the property. In other words, it is now definitely established that the only sums which are properly deductible from the cost to reproduce the plant are those sums which would be required as shown by an actual inspection to put it into proper condition. (*Pacific Gas & Electric Company*, 265 U. S. 403.)

These principles were applied in the *Roanoke Water Works* case, Virginia, P. U. R. 1925-B, 303, after court review; also in the *Carson Water Company* case (P. U. R. 1925-A, 343), where the Nevada Commission held that accrued depreciation must be based on inspection, regardless of the actual costs or the reserve set aside on the books of the Company. In this case the reserve was much lower than the depreciation, as ascertained by inspection; but this is unusual.

Turning now to the question of what property should be excluded from the rate base, we find that water works must be treated liberally in regard to excess building. In general, a commission or court should be very loath to exclude property on the ground that it was not immediately useful, because, water being such an essential commodity, if a company is to keep the service abreast of the demand, it is bound to anticipate the needs of its customers long in advance, and it is much better for it to err on the side of too great provision than of too little.

In the Ashland Water Company case, the Wisconsin Commission recognized this principle, and allowed the Company to include in its rate base reservoirs and intake pipe, which would undoubtedly have been excluded under a strict application of the principle that only such property as is used and useful shall be included. (*Ashland Water Company*, P. U. R. 1925-A, 707.) Similarly, the California Commission held that lands acquired by the Company for the protection of its watershed must be included in the rate base, although they were perhaps not strictly used and useful. (*San Jose Water Co.*, P. U. R. 1925-C, 370.)

The principle of liberality was, however, violated undoubtedly by the Missouri Commission in deducting a main not yet in use, but which would necessarily come into use in the near future. (*Capital City Water Company*, P. U. R. 1925-D, 41.)

II.

What is a fair rate of return for a water utility, is one of the elements most difficult to prove.

In most rate cases, no special proof by financial or other experts is

supplied, and apparently it is considered a matter of more or less discretion by the commissions. The principle is clearly established that the rate of return must be based on market value of money, and must be sufficient to permit the company to command capital, so that it will flow readily into the enterprise.

In the Mystic Valley Water Company case, the Connecticut Commission attempted to state what should be considered in fixing a fair return, summarizing as follows, namely: That it should be based on market value of money, the fair value of the property, the amount of the fair value over the actual investment or book value, the financial history as to payment of dividends, the amount of surplus invested in plant equipment, and the general history and record of financial operations and the service rendered. These are mere generalizations. It is hard to see how the bearing of any of these elements is specific enough, or susceptible of precise proof, to serve as any accurate measure of fair return. It is possible to give such specific proof. For instance, it can be shown by statistics how water-works securities compare with securities in general respecting the yield demanded by the investor, and other factors can be similarly presented statistically.

It is also obvious that interest rates varying in different parts of the country, the rate of return ought likewise to vary.

The following tabulation is significant on the rate of return:

3% on original cost clearly inadequate, California, *San Jose*, P. U. R. 1925-C, 370;
5% sufficient, Connecticut, *Mystic Valley Water Co.*, P. U. R. 1925-D, 385;
5.8% too little, Washington, *Mountain Springs Water Co.*, P. U. R. 1925-D, 645;
4.57% too little, Nevada, *Carson Water Company*, P. U. R. 1925-A, 40;
7% fair, *Ibid*;
7%, California, *Bell Water Company*, P. U. R. 1925-D, 1;
7%, New Jersey, *Washington Water Company*, P. U. R. 1926-C, 107;
7%, Wisconsin, *Merrill City Water Works Co.*, P. U. R. 1924-D, 131;
7%, Pennsylvania, *Enck* v. *Biglerville Water Co.*, P. U. R. 1925-E, 110;
7%, Wisconsin, *Ashland Water Company*, P. U. R. 1925-A, 705;
7%, Virginia, *Commonwealth* v. *Roanoke Water Works Co.*, P. U. R. 1925-B, 588;
7.4%, New Jersey, *Bound Brook Water Company*, P. U. R. 1925-B, 430;
7½%, New Jersey, *Middlesex Water Company*, P. U. R. 1925-A, 1;
8%, Missouri, *Capital City Water Company*, P. U. R. 1925-D, 41;
8%, Missouri, *St. Joseph Water Co.*, P. U. R. 1926-B, 76;
8%, Montana, *Fortine Water Works*, P. U. R. 1925-B, 535;
8%, Washington, *Department of Public Works* v. *Lake Forest, etc.*, P. U. R. 1926-C, 422;
8% just and reasonable, 10% excessive, Washington, *Carson Water Company*, P. U. R. 1926-A, 173.

In the St. Joseph Water Company case, the Missouri Commission tabulates a number of cases upon which it relies in fixing the rate at 8 per cent., as follows:

8%, *Louisiana Water Co.* v. *Missouri Public Service Commission*, 294 Fed. 954;
7%, *Merrill City Water Works Co.*, Wisconsin, P. U. R. 1924-D, 131.

The Commission stated that it ordinarily would allow 8 per cent., but because of decreasing population served, reduced it to 7 per cent.

8%, New Jersey, *Acquackanonk Water Co.* v. *Public Utility Commissioners*, P. U. R. 1924-E, 436; 125 Atl., 33;
8%, Idaho, *Re Consumers Company*, P. U. R. 1923-A, 418;
8%, New Hampshire, *Exeter Water Works*, P. U. R. 1923-B, 339;
7½%, New Jersey, *Flemington Water Company*, P. U. R. 1923-A, 156;
8%, North Dakota, *Logan* v. *Bismarck Water Supply Co.*, (N. D.), P. U. R. 1923-B, 450;
8%, West Virginia, *Re Tygarts Valley Water Co.*, P. U. R. 1923-C, 151.

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8%, *Brush Electric Co.* v. *Galveston*, 262 U. S., 443;
7½%, *Minneapolis* v. *Rand*, 285 Fed., 818;
7%, *Monroe Gas Light & Fuel Co.* v. *Michigan Public Utilities Com.*, 292 Fed., 139;
8%, *Cumberland Telephone & Telegraph Co.* v. *Morgan* (U. S. Dist. Ct.), May 10, 1924;
8%, *Mobile Gas Company* v. *Patterson*, 293 Fed., 208;
8%, *Alton Water Co.* v. *Illinois Commerce Commission*, 279 Fed. 869.

One novel point in connection with rate of return was discussed by the Commission in the San Jose Water Works case, *supra*. There it was contended that because the Company had a large proportion of its capital represented by bonds at a low interest rate, it should not receive the same rate of return as other companies less favorably situated. The Commission held that the Company was entitled to the benefit of its low interest rate, and should not be penalized for the same, and that its rate of return must be the same as that of less favorably situated companies.

Of course, this is clear on principle. A company is entitled to a fair return on the entire fair value of its property, regardless of how it is actually capitalized; and this is generally recognized by the authorities.

III.

In connection with the operating expenses, there are but few points which require any special comment.

The right to amortize, through operating expenses, the cost of rate litigations, is, of course, clearly established.

The principle was applied in the *San Jose* case (P. U. R. 1925-C, 431) as to the expenses of (1) a rate case; (2) the unusual expenses due to a drought, and emergency pumping; and (3) to unusual expenses connected with paving, where the Company had to lower or extend mains because of a paving program of the city.

In the Bound Brook Water Company case, the Company was allowed to amortize the expenses of its rate litigation in reference to operating expenses. (*Bound Brook Water Company*, P. U. R. 1925-B, 432.)

In the Boise Artesian Water Company case, the Supreme Court of Idaho held that the cost of litigation to establish franchises should be included in the rate case and the balance amortized.

The following have been held as proper to be included in operating expenses:

(1) Rentals, for leased property, only up to the point where fair (*Indiana Power & Light Company*, P. U. R. 1925-C, p. 85); (2) Payments for water diversion; (3) Federal taxes (*Middlesex Water Company*, P. U. R. 1925-A, 1); and (4) Increase in local taxes following rate case valuation (*Bound Brook Water Company*, P. U. R. 1925-B, 432).

The following have been excluded from operating expenses and disapproved:

(1) Athletic club dues; (2) Fees paid to a Taxpayers' Association, Board of Trade, Chamber of Commerce, and other personal expenses of employees; (3) Advertising in newspapers and magazines; (4) Cost of maintaining unused property (*Indianapolis Water Company*, P. U. R. 1925-C, 431); and (5) Surveys for additional water supply (*Matamoras* v. *Matamoras Citizens Water Co.*, P. U. R. 1925-B, 136).

The danger of excluding surveys for additional water supply needs little emphasis. Instead of discouraging a company from spending money to anticipate and provide for the needs of its service, such expenditures should be encouraged.

The annual allowance for what is ordinarily known as depreciation reserve, or what would be better called, a "reserve for retirements," varies somewhat, but in the cases of this period allow approximately $1\frac{1}{2}$ per cent. of the depreciable property.

IV.

In estimating revenues, the Commission in the Roanoke case held that fees for special services, such as tapping and turning on and off, should be included in the total revenue, and that non-operating revenues should also be included in estimating the return. This was a small item, but the principle involved is an important matter. Since the purpose of the proceeding is to determine the fair return from the rates, certainly no revenues should be included except those derived from the rates. If the Company is able by making successful investments to increase its revenues or, by some other source of income, to get a higher return than that which is allowed to utilities, it should not be penalized by having its rates reduced. The fair *value* of the service which it renders, and which these rates are supposed to measure, would not be affected by these outside activities.

V.

We now come to the discussion of the distribution of the rates.

The origin of rate regulation was an effort to eliminate discrimination. Since the rate is supposed to be the fair measure of the value of the service rendered, and consumers require various services of different value, it is clear that there may be considerable differences in the charges made to different customers, or classes of customers, without discrimination. The classification of the rates may be based on the value of the services or on the cost of the services. It is now generally recognized that efforts to classify rates on value of service are futile, because of the difficulty of ascertaining anything precise or fixed to serve as a measure.

It may now be considered as definitely settled by the Supreme Court that the only way in which discrimination can be successfully eliminated is to base the rates on a cost analysis, showing what each class of customers should fairly contribute. (*Banton* v. *Belt Line Company*, 45 Sup. Ct. Rep. 535.)

Progress along these lines is being slowly made by water companies throughout the country. The growing disapproval of flat rates and the insistence by commissions that the entire service must be metered, is a recognition of the principle. During the period under review, we find eleven cases in which meters were ordered, and only two exceptions.

In *Mystic Valley Water Company*, P. U. R. 1925-D, 385, the Commission held the Company was excused from installing meters because of its inability to finance the same.

In *Patrons* v. *Mountain Springs Water Company*, P. U. R. 1925-D, 645, although the Company was ordered to meter the entire system, an exception was made in regard to a part-year service. This might be quite consistent, since the largest element in part-term service is the readiness-to-serve, and the costs vary with the capacity of the plant required rather than with the amount of water taken.

In general, the reasons given by the commissions for ordering meters is the necessity of conserving water and preventing waste; also that it is the only fair and accurate way of ascertaining the costs and preventing discrimination.

There are a number of cases during this period where free service to municipalities or unduly low rates to municipalities have been set aside as discriminatory. (*Augusta Water District*, P. U. R. 1925-B, 234; *Monidah Trust* v. *Northern Pacific Railway Co.*, Montana, P. U. R. 1925-A, 750; *St. Joseph Water Company*, Missouri, P. U. R. 1926-E, 76.)

In the same way, it was held that free service to owners of the utility was discriminatory (*Fortine Water Rates*, Montana, P. U. R. 1925-B, 535), and that lower rates made for irrigation purposes and for other purposes, where the costs were the same, was discriminatory. (*Re Bell Water Company*, California, P. U. R. 1925-D, 1); also that to give factories lower rates than other large consumers in the same class, was discriminatory. (*In re Marlton*, New Jersey, P. U. R. 1926-B, 856.)

Of course, it is many years since a proper measure of the value of public fire service charges was devised, and yet it is surprising how many jurisdictions there are in which water companies still charge for fire service at a flat rate or a hydrant rental.

It is astonishing to find at so late a date the Nevada Commission stating:

"We know of no basis upon which to segregate that portion of the plant investment which might be chargeable against fire protection;" (P. U. R. 1925-A, p. 347.)

and the Connecticut Commission fixing a fire service rate by some arbitrary method instead of the inch-foot charge. (*Mystic Valley Water Company*, P. U. R. 1925-D, 385.)

Contemporaneously, the Middlesex and Ashland cases applied the inch-foot charge, which is well established in Wisconsin and New Jersey.

The New Jersey Commission applied this method in the *Bound Brook* case, P. U. R. 1925-B, 425; and *In re Shorewood*, P. U. R. 1925-B, 43, the Wisconsin Commission stated that their analyses showed that in the average plant from 50 per cent. to 70 per cent. of the plant was assignable to fire protection service, and fixed the rate on plant division, even though the pressures were low.

A novel point relating to this method of charge was passed upon by the New Jersey Commission in the *Elizabethtown Water Company* case, P. U. R. 1925-E, p. 630.

There the Commission had included in the mains upon which the inch-foot was calculated water mains located on grounds of a manufacturing company, to which there were no public hydrants, but which were cross-connected to other mains, aiding the pressure which could be used throughout the city. This was challenged by one of the municipalities, and the inclusion of these mains was sustained by the Commission.

As is illustrated by this case, the whole basis of the inch-foot charge rests on the theory that the main element of fire protection is a readiness-to-serve, and not the quantity of water used. The cost of maintaining a plant large enough to produce a sufficient quantity of water to meet the sudden emergency of fire, is the cost of the fire-protection service, and the rate should be sufficient to cover this. Since such cost corresponds roughly with the size and length of the mains, a rate based on the inch diameter foot length of mains large enough for fire protection (that is, 6-in. and over) is a fair measure of a fire-protection service. It makes little difference whether the hydrants are attached to all the mains or not, or whether any water is actually drawn from all the hydrants which are attached, so long as the mains are a necessary part of the system for rendering the service.

Closely connected with the public fire-service charge, is the private fire-service charge. It is now almost without exception the rule that sprinkler service and private fire protection must be paid for by the private

customer requiring the same. The rate is usually based on a capacity charge. (*Schwarzenbach-Huber Company* v. *Hackensack Water Co.* (N. J. Com.), P. U. R 1926-A, p. 701, citing cases from Iowa, South Carolina, and Massachusetts.)

McFuson & Foster Co. v. *Evansville* (Indiana Com.), P. U. R. 1925-E, 248, citing cases from Tennessee, Minnesota, Iowa, Washington, and Nevada.

Failure to charge for fire-protection service was held discriminatory in the *Augusta Water Company* case, Maine, P. U. R. 1925-B, 234.

It is becoming recognized more and more that in order to take care of the fixed costs, which vary with the capacity required by the consumers, a fixed charge is a proper form of rate and should be preferred to minimum rates.

Mystic Valley Water Company, P. U. R. 1925-D, 385, is the only case arising in the period under survey where this was recognized, and at the same time the Missouri Commission approved a minimum charge. (*Lexington Water Company*, Missouri, P. U. R 1926-C, 659.)

As already pointed out, seasonal consumers require a large capacity of plant in comparison with the quantity of water taken by them, and therefore a fixed charge is a proper measure of their proportion of costs, and any other charge is discriminatory. This principle was violated by the Commission in the *Carson Water Company* case, P. U. R. 1925-A, 347.

In that case, the Commission fixed a minimum charge for a seasonal customer, at lower than the minimum charge for other consumers, although increasing his meter charges. The Commission also gave the schools lower minimum rates during the months when they were shut down than during the months when they were actually operated, though the fire-protection demand still existed and the size of the plant required to protect them was just as great during these off-peak periods as when they were actually using water.

There were two cases, during the period under survey, where it was recognized that a comparison of rates in other communities has no substantial value in determining reasonableness, unless conditions are similar. (*Sullivan* v. *Hingham Water Company*, Massachusetts, P. U. R. 1926-C, 371; *Carson Water Company, supra.*)

VI.

As already stated, the question of rates is closely related to the question of service.

It is plain that if a company can be compelled to enter into unprofitable territory, the losses due to that service will have to be made up to it sooner or later by other consumers, which would mean that such consumers were paying a larger proportion of the costs than their service required. This would be a clear violation of the rule against discrimination, as above set forth.

Accordingly, we find a general recognition of the principle that a company cannot be required to extend into inadequate territory without being guaranteed a fair revenue on the investment. (*Department of Public Works* v. *Lake Forest*, P. U. R. 1926-C, 422; *Sacramento* v. *North Sacramento L. & P. Co.*, P. U. R. 1926-C, 600; *Wolf* v. *Waterloo*, Wisconsin, P. U. R. 1925-A, 182.)

In the Waterloo case, the Commission refused to order an extension which would not pay, and was not necessary to improve the general service, even though it would make a sewer useful, which, at the time, was inadequate because of no water. The Commission held that the question of whether the sewer should be used or not was up to the health authorities of the city, and not the Commission.

An interesting question was passed on by the New Jersey Commission, in connection with street paving.

In *Township Committee* v. *General Water Supply Co.*, P. U. R. 1925-A, 388, the township applied to the Commission to order the Water Company to build extensions because of a street-paving program which was pending. The city had an ordinance which would prevent the cutting of the paving within two years after it was laid, and therefore endeavored to compel the Company to extend into territory not yet settled. The Commission held that it had no power to order such extension.

The Lake Forest case, above mentioned, presented another rather novel question. There the Company had a limited source of supply, and the Commission held it would not be permitted to extend its service to new customers until it had secured a sufficient supply for the existing customers. A somewhat different view was taken by the Texas Court of Civil Appeals in *Allen* v. *Park Place Water L. & P. Co.*, 266 S. W., 219. The court held that a water company must supply all within its franchise territory for which it had facilities at the time, even though it feared a future demand beyond its capacity.

One of the most important problems confronting a water utility, due to the peculiar nature of its service, is this question of limiting extensions where the water supply is not sufficient. It is obvious that a water company differs from other utilities, because it is dependent on a natural resource. When a gas company, telephone, or electric company reaches the limit of customers which can be taken care of from existing plants, they have only to add to their equipment to meet the demands of service, whereas a water company may find its capacity to serve entirely limited by natural resources which cannot be indefinitely expanded. As a matter of practice, a water company should maintain a periodic survey to anticipate the needs of their service, and determine as far in advance as possible the growth of the demand. On principle, it would seem, then, that the rule laid down by the Washington Commission, that the service should not be extended to new customers at the expense of the service to the old customers, was sound, and the company ought to be able to limit the new customers

that it would take in excess of its existing capacity, just as it would refuse to extend into unprofitable territory.

Of course, the company cannot be ordered to supply customers outside of its franchise territory. (*Schade* v. *Lansdale Water Company*, P. U. R. 1925-C, 187; *Clawson* v. *Johnstown Water Company*, Pennsylvania, P. U. R. 1925-E, 788.)

Within this territory, however, the general rule is, that to the limit of its facilities it must serve all applicants. If it refuses to do so, the commissions will refuse to protect it from competition. (*Re Harmar Water Company*, Pennsylvania, P. U. R. 1925-D, 862; *Re Keansburg*, New Jersey, P. U. R. 1926-A, 160.)

The commission may even refuse to protect the company from competition where the same, or more adequate service, can be secured at lower rates. (*Kearney* v. *Passaic Consolidated Water Company*, P. U. R. 1925-B, 437.)

An interesting case, relating to continuing unremunerative service, arose in California, and is presented in *Priest* v. *Parkhill*, P. U. R. 1926-D, 37. There the public utility sought to discontinue an unremunerative service. The Commission held, that since it had never applied for increased rates, and there being no proof that the rate could not be made remunerative, it would not be permitted to discontinue the service.

A similar decision is found in *Massena* v. *St. Lawrence Water Company*, 214 N. Y. Supp. 113, where the New York Supreme Court granted a mandamus to compel a water company to make an extension within its franchise territory, where the defense was that the rates were inadequate, but the court held that the company had taken no steps to secure more adequate rates.

VII.

During the period under review, only four cases arose which did not involve questions of rates, but related solely to rules and regulations, or matters of practice. These are outside of the scope of this article.

In addition, there were five cases dealing with matters of practice having an important bearing on rate-making.

In *Bayonne* v. *Passaic Consolidated Water Company*, P. U. R. 1926-A, 285, the Board refused a rehearing in a rate case after two years, where there was no newly discovered evidence or additional facts, and held that any changes which had occurred during the two years should be grounds for a new hearing, and not for a rehearing.

In *Alton Water Company*, 145 N. E. 683, the Illinois Supreme Court, in construing an Illinois statute, held that the City Council had no power to bind later councils by fixing rates once and for all for 30 years, but could only fix reasonable rates from time to time during 30 years. This is a well-recognized principle of municipal law, but the case presents an interesting application.

Another group of cases dealt with questions of what constitutes a public utility, subject to regulation by a commission.

In *Humbird Lumber Company* v. *Public Utility Commission*, 228 Pac. 271, the Idaho Supreme Court had to determine whether a water-works department of a lumber company was subject to regulation as to its rates. In this case the lumber company secured fire protection to its own mill through a water works which it had built. It sold its surplus to a railroad. A water company, supplying water to the territory, desired the business of the railroad and sought to prevent the lumber company from competing with it. It was held by the court that the lumber company was not a public utility and not subject to the jurisdiction of the commission.

The case contains a very interesting discussion of the essentials of a public utility, and a recognition that the dedication of the property to the service of the public is the test.

In *Kearney* v. *New Jersey Suburban Water Company*, P. U. R. 1926-C, 41, it was held that a wholesale company distributing water to various communities at wholesale for distribution to local customers, is a public utility and subject to regulation as to its rates, even though it was organized under a General Corporation Law.

One of the most important and novel questions which arose during this period has a direct bearing on rate-making. This was the case of *Passaic Consolidated Water Company*, P. U. R. 1926-B, 193, where the Commission not only directed the form in which the accounts of the Company were to be kept, but actually attempted to prescribe the amounts which were to be set up on its books, and held that the Company could not substitute the opinion of its engineer as to the value of the property, as set up on its books, for that which the Commission prescribes. Of course, it is a well-recognized principle that a water company must keep its accounts in the form prescribed by the commission. (*Rolio* v. *Miller Ditch Company*, Utah, P. U. R. 1925-E, 125.) But it has generally been the impression that this does not give the commission power to dictate the actual entries. On principle, the power of the commission should only extend to formal matters of classification and accuracy.

People ex rel. New York Railway Company v. *Public Service Commission*, 223 N. Y. 373.

Certainly, if the entries are dictated, whatever estoppel they work should not be on the company that keeps them, but on the State that prescribes what they shall be.

A study of all the foregoing cases, reported since January 1, 1925, convinces one that the principles underlying the problems of rate-making are pretty definitely settled and becoming more and more recognized. It is clear, too, that the difficulties in application of the principles are being gradually surmounted and the problems of proof solved. Much work

remains to be done on such questions as assembly value of real estate, valuation of water rights, and similar problems of valuation; in cost analysis and service matters as relating to rate distribution, and in similar specific problems still brought into dispute before the commissions. How fruitful such study may prove is demonstrated by what has already been accomplished and appears from the review of these cases. It is also apparent how important it is that each case, as it arises, should be carefully prepared and presented so as to obtain the full benefit of the established law.

Discussion.

Caleb M. Saville.* I think we are indebted to Mr. Wherry for a very interesting and instructive paper, — a paper such as very seldom comes before this Association, but which is of great value to it. All matters have been presented in considerable detail and very plainly, so that we can get the legal thought.

He spoke of the Mystic Valley Water Company and used it as an example; as I happened to be retained by that company in its rate case, perhaps some of their matters which came up may be of interest.

In the first place, the Connecticut Public Utilities Commission is a very excellent body. It is almost ideal in its formation. I think I can say that there are no politics in it in any way whatsoever, and there are no strings tied to it. The chairman is a lawyer with a very keen analytical mind; of the other two members, one is a civil engineer, a railroad engineer and a man of broad experience on construction work and operating work; and the other member is a very successful business man of broad experience and sound judgment. In view of these conditions I am sure that any decision which this commission makes can be said to have been given only after very mature consideration of all of the facts.

In the case of the low rate of return which has been referred to by the author, there were a number of pertinent matters which had a bearing besides the secondary supply which the author mentioned, although that was a major consideration. I might say at the outset also that this company is rather peculiar in its layout. The secondary supply which is referred to was from tidewater, and the community that objected most strenuously to any increase in rates had just bought a new pumping engine from which they anticipated great service by throwing their suction hose into the river and pumping direct. Tidal conditions and very long hose lines did not worry them in the least. A part of the district also was not adequately served with water, and that was of great importance when you consider that the increase allowed added approximately 50 per cent. to the previous revenue.

The author spoke of going value and some of the things with which that is confused. I have found that going value is sometimes sadly mixed with good will in some minds, but that I think will be straightened out shortly.

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The value of service is a thing that should be given the most consideration. We have all heard this discussed and have been rather alarmed, sometimes, at the apparent tendency of decisions, yet, when you come to get down to facts, "all the tariff will bear," that is all that the service is worth to consumers. I think you will see the justice of such decisions.

The question of main-pipe extensions is one that should receive considerable consideration from a body such as this, and I think that it might be a most interesting subject for discussion at some of the meetings. There is also the question of extending services under streets which are going to be paved, and from which there is no return in sight; and particularly whether or not a service should be put in a street and left dead for a long time. These, I think, are matters that the superintendents and the operators can discuss better than anybody else.

MALCOLM PIRNIE.* I would like to ask two questions. One is in relation to the extension of large cast-iron mains under newly paved streets, where the extension is ordered by the city and a penalty is placed by ordinance on the water company if within a period of five years any excavation is made in the newly paved street, — whether or not this tendency on the part of the city to require complete installation of water works under newly paved streets will not tend in the future to establish, as an element of value of a water-works system, the value of the paving above the mains. I think many of the old arguments were that the mains were there and if the city came and laid the pavement over them it did not cost the company anything.

At the present time there is one case where 36 miles of paving have been laid in a rapidly growing Florida city, where, owing to the very few consumers on those streets, 2-in. pipe would be sufficient for the next two or three years, but the water company has been ordered to put in 6, 8, or 10-in. mains, anticipating the future. Considerable expense is placed on the water company at this time so that there will not be any interference with the pavement within a period of five years.

Another point is that the city also requires the installation of the service connections to the curb, and requires them to every lot, and 90 per cent. of the lots probably being vacant it is a rather severe requirement on the water company; and the question comes up as to whether it would not be legal to make a service charge on that connection against the lot.

A second question I want to ask Mr. Wherry is relative to the distribution of charges for water-supply services. Where there is a definite attempt at the present time in rearranging rates so that they will be equitable and everyone will pay his fair share of the cost of water service, would it not be proper to place a charge on private fire connections? In this connection I think there is a good deal of misunderstanding among certain influential insurance people within the community itself, and they argue that, inasmuch as the service is taking no water it should pay nothing for it;

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all they want to do is to pay the cost of installing a 6-in. connection to the main. I think that is a place where coöperation between the insurance men and the members of this Association can help to straighten out that point of misunderstanding and show that there is a distinct value in that connection to the distribution system, — the readiness to serve, which is identical with the readiness to serve the other consumers who use water. Those consumers pay for the water they use, but they also pay a certain amount each year for that ability to draw water at any time they wish. I am hoping, in looking forward to the future, that that readiness-to-serve charge will be accepted for a fire connection.

I would like very much to have Mr. Wherry answer whether or not he believes the tendency is to allow paving over the pipes in these particular circumstances, and whether or not it might be legal to make the service charge against the lot where you are required by a municipality to put the service pipe in before the water is actually taken on the property.

MR. WHERRY. Well, of course, if the company does make the extensions before the paving is laid, the mains must be included in the rate base. Now, in those cases that I have had to do with I have had less trouble in regard to this problem of paving over mains — I mean, extension in advance of paving streets — where the companies charge the inch-foot charge for fire service. There the city includes those mains which are laid in anticipation of street paving. They include those mains in the rate base and pay an annual foot charge per foot of main — that is, a charge per inch of diameter and per foot of length of those mains, so that the company derives a benefit from the city for those mains. That seems to be a pretty good solution of the problem, because that service of the company in laying those mains is a benefit to the whole community. In these cases where I have had to work it out we have got the city to pay a larger charge on those mains because there is no domestic charge to make up the additional cost of it. That may cover your point.

Now, on the question of a private fire service for sprinkler systems, every case that has come to the courts has held that private fire service must be paid for by the consumer that gets it, and there are cases in at least six different jurisdictions where it has come into court. In the paper as it is printed you will find a reference to two cases which came up before the commissions. One of those cases was in New Jersey, where the sprinkler people came and strenuously attempted to have eliminated from a rate schedule, approved by the New Jersey Commission, the sprinkler charge, which was a capacity charge based on the capacity of the service connection; and the Commission refused to omit it. The other case is in Indiana, where the Commission likewise fixed a charge for the sprinkler service on a capacity basis. That New Jersey case is *Schwarzenbach-Huber Company* v. *Hackensack Water Co.*, P. U. R. 1926-A, p. 701; and the Indiana case is *McFuson & Foster Co.* v. *Evansville*, P. U. R. 1925-E, p. 248.

There was another case in Maine, the *Augusta Water Company Case*,

P. U. R. 1925-B, p. 234, where it was held that the failure to charge for private fire protection service was discriminatory.

The only three cases which are reported during the period cite decisions of the courts holding that it must be a charge borne by the consumer who takes the service, and it must be a capacity charge.

W. C. HAWLEY.* I am very glad to hear the author of the paper call attention to the fact that few of the commissions have fixed rates for public fire protection on the basis of actual cost. Wisconsin, I think, has come the nearest to doing that of any of our Commissions, but most of the commissions have fixed rates which are absolutely discriminatory when it comes to the matter of public fire protection. If they would fix public fire protection rates upon the basis of actual cost, the rates for domestic service and industrial service would be reduced accordingly. Yet when we think of the utterly inadequate rates which water companies have had for public fire protection in the past, perhaps it is not surprising that the commissions have not raised those rates to what would seem to be an unreasonable extent to the people that are served and who do not understand rate-making, and to the politicians who have to fix the tax rates.

I am glad that he brought up the matter of the value of paving over mains. That has been one of the large elements of value which the commissions and courts have refused to include. This refusal has been explained because the pipe was laid before the pavement was laid. The fact that the cost of reproducing the pipe under present-day conditions was being considered and that the pipe could not possibly be reproduced without taking up and replacing pavement, has not been overlooked, but the courts and commissions have refused to consider it. Changed conditions which increase or decrease the reproduction value of other units are taken into consideration and yet the value of the pipe has been estimated without any consideration of pavement in the value called "reproduction value." It would be interesting to know how the value of a pipe system would be arrived at in case of a transfer of the water-works system from a water company to a municipality. Surely pavement would have to be considered in such a case, for manifestly the pipe in place under a pavement would be worth more to the municipality, and the municipality could afford to pay more for it in order to avoid the increased cost of taking up and replacing pavement in order to lay new pipe — to say nothing of the inconvenience to traffic while the work was going on.

The question of laying service lines ahead of paving is one that is always with us. In strictly residential districts it may be possible to do this where the frontage of lots is fixed and other conditions favorable, but it is less than a year since the speaker put in three service lines in front of three 40-ft. lots, the service lines being paid for by the owner of the lots, with the understanding that the water company would reimburse him for the cost of the service lines when houses were built and domestic service

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taken through the service lines. We now find that the three lots have been subdivided into four; four houses built; and we are confronted with the necessity of putting in a fourth service line through the new pavement.

Some years ago in one of our towns there was a change in grade of a railroad, which involved very extensive changes in street grades and much new pavement. At that time service lines were put in at the expense of the consumer. After some negotiations council decided that it would pay the water company for the cost of putting in the new service lines, council to be reimbursed by the owners of the properties who took service from these lines. Between 20 and 30 service lines were put in, and up to the present time probably two-thirds of them have been put into service. Of these, just one was found to be of the right size and in the right location when service was demanded. The others have either been not where they were wanted or they have been too small.

The matter of extensions is another problem with which water companies especially are constantly confronted. They have no power to assess a frontage charge to cover part or all of the cost of making the extension, as is done by some municipalities; and since they cannot make up deficits from taxes, they should have some rule which would limit extensions to those that the revenue received therefrom would carry the cost of the investment and the output cost of service. That part of extensions which the revenue will not carry should be advanced by those demanding the extension, this to be returned to them as added service is taken and additional revenue received. I believe that New Jersey is the only State of which the commission has laid down a fixed rule covering this matter. There the water company must invest $3 for every dollar of annual revenue. Some of the other States have made rules in certain cases but have applied no general rule as has been done in New Jersey.

It seems as though the inch-foot basis of charge for public fire protection, while it has its good points, is a rather unnecessary refinement. If the water company is receiving in total a fair return for furnishing public fire protection, it is immaterial whether it is paid in a lump sum or is distributed over some such unit as the length of mains, except that it is important that there should be a proper payment for extensions to the distribution system. So far as actual fire service is concerned, it makes no difference whether the pipe in a given block is 6-in. or 24-in. provided the distribution system as a whole is properly designed. After all, it is a matter of the total amount to be paid and the distribution of that amount over some unit to which it can be applied.

I would like to ask the author if he can tell us what the decisions have been in regard to the service charge. He spoke of a minimum rate. I think we are getting to a point where we are going on from minimum rate to a service charge as a more equitable distribution of cost of service, and I am wondering if there have been any decisions regarding the service charge.

MR. WHERRY. There were not very many cases during this particular period where that came up. There were only three cases during this period where the question of service charge came up. I would say that in general it was becoming recognized that the fixed-cost charge, or a fixed charge, was a proper form of rate rather than a minimum rate.

The Mystic Valley case was one where they recognized that, but in a Missouri case they approved a minimum charge, although it was contended that there should be a fixed rate without a minimum amount of water. In the Carson Water Company case the Nevada Commission violated almost every principle of proper rate-making and allowed lower minimum rates during the summer months, and also lower minimum rates for schools and hotels, although the capacity required in each case was greater. But in some of the earlier cases in New Jersey and in Wisconsin, and in cases prior to 1925, you will find a discussion of it, and my impression is that the minimum charge is going to give way to a fixed-service charge, varying with the capacity of the service connection and capacity of the meter. I am sorry there are not more cases.

ARTHUR H. PRATT.* (By letter.) In the decision in the Matter of the Fixed Capital Accounts of the Books of the Passaic Consolidated Water Company, rendered January 7, 1926, by the Board of Public Utility Commissioners of the State of New Jersey, the following appears:

"This case, instituted by the Board, arises by reason of the fact that the Passaic Consolidated Water Company has set up on its books of account figures for fixed capital on a different basis from that fixed by the Board in its decision in the matter of the application of the Acquackanonk Water Company et al, for approval of a consolidation agreement forming the Passaic Consolidated Water Company." . . .

"These five companies submitted a petition to the Board asking it to approve a consolidation of the above named five companies into a new company to be called Passaic Consolidated Water Company." . . .

"The books of the existing companies show definite figures (presumably the historical costs, A.H.P.) with respect to the assets and liabilities of the respective companies as now shown in their annual reports to the Board and there can be no prejudice resulting from the setting up of the *continued balance sheet on the basis of the combined book costs of the respective companies after eliminating inter-company items.*" . . .

*Chief Engineer, North Jersey District Water Supply Commission.

CHLORINE STUDIES AND SOME OBSERVATIONS ON TASTE-PRODUCING SUBSTANCES IN WATER, AND THE FACTORS INVOLVED IN TREATMENT BY THE SUPER- AND DE-CHLORINATION METHOD.

BY NORMAN J. HOWARD* AND RUDOLPH E. THOMPSON.†

[*Read September 15, 1926.*]

Increasing attention to the subject of taste causation in domestic water supplies and to the treatment and prevention of same, has resulted in extensive studies and researches being made throughout the world. In Canada, the city of Toronto has been foremost in encouraging research productive to the health and comfort of its citizens, particularly along public health lines. The water purification laboratories were established in 1911 and extensive and valuable research work has been undertaken since that year. The work carried out has not only been productive of information of general value to those engaged in the treatment and purification of water, but has resulted in great economies being effected in the operating costs of the Toronto plants.

The object of the authors in this paper is chiefly to discuss tastes and odors in chlorinated water, resulting from the presence of phenolic substances and those of unknown origin. It is not proposed to consider tastes or odors caused by the presence of gaseous compounds or those associated with microscopic organisms which are known to impart taste-producing properties to water.

In Toronto, as in many other cities, taste troubles occurring in the water can be largely said to date back to the time when sterilization was commenced. Calcium hypochlorite was applied to the raw water in 1910 when the city was in the throes of a typhoid epidemic which resulted in a death rate of 40.8 per 100 000. The sterilization of the water was successful in abating the epidemic, and the treatment was maintained as part of the routine procedure. Filtration followed, and later, with the introduction of liquid chlorine and closer control, the number of complaints from taste became less. At the present time complaints are not usual, excepting during occasional periods when the whole supply develops a pronounced medicinal taste, which is admittedly objectionable. During 1925 and 1926, several such periods occurred, chiefly in the early spring and in the fall of the year. Super-chlorination, followed by de-chlorination with sulphur dioxide, was tried on the water in the laboratory with completely successful results. An appropriation of $32 000 was obtained for a year's experimental work and treatment, which included the purchase of two high-

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capacity chlorinating machines and other equipment, but at the last minute the treatment was abandoned on account of objection being raised to the addition of further chemicals to the city water. An intensive taste recently developed and experiments again demonstrated the effectiveness of the super- and de-chlorination process. As a result of this it was decided to immediately proceed with the new treatment which is later described in this paper.

It is proposed to briefly consider the chief causes of the medicinal or iodoform taste and odor which are frequently encountered following chlorination of water, particularly when small applications of chlorine are made. These are industrial trade wastes, chiefly derived from gas works and coke ovens, the products of decomposition of organic matter and those of unknown origin. Of the industrial wastes, the phenol and cresol group must be regarded as the most important. What actually results from the decomposition of organic matter is a matter of conjecture, but as in many cases similar tastes and odors occur following chlorination, it is reasonable to assume that the destruction or breaking down of the organic matter in solution results in the formation of phenoloid substances, which are recognized as some of the products of putrefaction. The industrial wastes alone, except in excessive quantities, rarely taste, but the presence of decomposing organic matter in solution imparts a peculiar earthy or mouldy taste which may develop a chemical flavor upon the addition of small or comparatively large doses of chlorine. The taste, however, can be partially broken down by excessive doses of chlorine.

In considering the question of the types of taste previously mentioned, it should be pointed out that there are a large number of references recording the presence of taste in water supplies in both Europe and America. Reference is made to some of the more important and conclusive cases and also to the research work undertaken. As to the actual cause of taste and methods of detection, pioneer work has been carried out in North America, but credit for the treatment must be given to European workers.

As far back as 1918, Race[1] stated that "creosote and tar oils have caused an odor resembling iodoform, and industrial wastes have also produced complaints." Taste resulting from phenol wastes was reported in Milwaukee in 1919 by Brown,[2] who was able to show that 1 part of phenol in 500 million of water chlorinated at the rate of 0.3 p.p.m. was objectionable for both drinking and cooking. Filtration and ozonization was effective but expensive. In 1920, the American Gas Association[3] published an excellent Committee Report on the disposal of waste from gas plants stating, it was claimed, that the presence of phenol, cresol, hydrocarbons of the benzene series, anthracene and naphthalene, in water, will impart a very disagreeable taste to chlorinated water. The waste from the ammonia stills of by-product coke and gas works produced the most pronounced taste, 1 part of still waste with 50 000 parts of water, giving a solution varying between 1 and 2 parts of phenol in 50 million parts of water,

and this, when chlorinated, gave a medicinal taste. During 1921, the Seventh Annual Report of the Sewerage Commission of Milwaukee[4] showed that ammonia condensation liquor contained some cresol, sulpho-cyanide, sulphur phenol, and other taste-producing compounds which were responsible for the periodical taste in chlorinated lake water. Observations made at the experimental plant showed that the activated sludge process of sewage purification destroyed the taste-producing properties of phenol and would afford some protection against taste if such wastes were discharged into the city sewers rather than into streams from which water supplies were directly or indirectly drawn. C. A. Emerson,[5] in 1921, reported on interference with water filtration plant operation by wastes from by-product coke ovens and gas works. This was followed by a detailed discussion by C. M. Baker[6] on the tastes, odors, and remedies suggested in the city of Milwaukee. An extensive investigation as to the cause of taste in the city of Cleveland was undertaken in 1922 by J. W. Ellms and W. C. Lawrence[7] who concluded that obnoxious tastes and odors were due to trade wastes from the industrial plants on the Cuyahoga River operating by-product coke ovens. They found, "When the water polluted with this waste is chlorinated, in the regular course of purification of the city's supply, a portion of the chlorine unites with the phenol and allied organic compounds forming substitution and addition products, which are foul smelling and tasting. The original polluting material is in solution and cannot be removed by filtration." It is of considerable interest to recall that at Cleveland not one sample taken from domestic sewers discharging into Lake Erie contained taste-producing substances, only the effluents containing mixtures of domestic sewage and trade wastes producing taste. Exhaustive work carried out in Toronto was reported upon in 1922 by N. J. Howard,[8] who published the first detailed figures relative to the amount of phenol and chlorine which combined and produced taste substitution compounds in water. The Toronto work showed that the iodoform taste occurred in the city water with a phenolic content of 0.006 part per million when only 0.20 part of chlorine was being added, confirming the observations made in the laboratory under artificial conditions, and that "applied chlorine in doses up to 0.10 p.p.m. does not produce taste in combination with phenol, when this latter substance is present in quantities up to 0.015 p.p.m. Doubtful taste may occur when chlorine is added in amounts between 0.135 and 0.150 part, with phenol present up to 0.015 p.p.m. The critical dosage range occurs when chlorine is added in amounts between 0.175 and 0.40 p.p.m. with the phenol ranging between 0.002 (1 in 500 millions) and 0.017 p.p.m. An actual combination of 0.22 part of chlorine and 0.007 part of phenol caused a water to both taste and smell of iodoform." The chief point established was that the critical figure which causes taste is close to the actual dose of chlorine which has to be applied in many cities, thus explaining why taste so often occurs. The report of the American Water Works Association,[9] published in 1922, contained very complete

information and a bibliography on industrial wastes in relation to water supply. W. Donaldson,[10] in a valuable contribution published in 1922, stated, "The evidence is conclusive that the presence of phenols in water results, after chlorination, in greatly intensified and disagreeable tastes and odors. The numerous sources of phenol pollution to our streams make the situation from the water-works standpoint quite serious. So widespread is the trouble from this source that the writer is tempted to say that where a water supply experiences disagreeable medicinal tastes after chlorination, and tests show the absence of free or residual chlorine, then the trouble is apt to be due to the presence, in the supply, of phenols which may be detected and measured." In the second progress report of the American Water Works Association[11] in relation to water supply, prepared in 1923 under the direction of A. L. Fales, it was reported that, "the tastes produced in chlorinated water have been variously described as chemical, creosote, medicinal, carbolic acid or iodoform. Persistence of taste in dilution as great as 1 part of waste to 10 million parts of water, or after passage by streams as far as 70 miles, has been reliably reported." Detailed reports on the tastes in the water supply at Marquette, Mich., due to phenols, and the remedies employed for overcoming these tastes, have been recently made by Paul Hansen.[12] Many other articles dealing with this subject have been published, but it was not until 1925 that an entirely new line of thought was introduced by B. A. Adams[13] in England, which was later confirmed by Sir A. C. Houston[14] in experimental work. Adams showed that some atmospheric constituent, probably phenols or allied substances, was absorbed by water and in the presence of chlorine produced a characteristic iodoform taste. He found that the taste did not develop if the water contained a trace of ammonia or an unusual amount of organic matter. It is of interest to record the fact that in America, excluding well-water supplies, amongst the worst-tasting waters following chlorination are those high in free ammonia and organic matter. In Toronto and other cities on the Great Lakes, the water which normally contains 0.002 p.p.m. of ammonia, rarely tastes, but as the free ammonia increases, as it does at times, up to 0.100 p.p.m. taste will assuredly develop. With the increase in ammonia there is also an increase in organic matter although to a lesser degree. Sir A. C. Houston[14] has stated that too much reliance must not be placed upon the presence of organic matter as an aid to taste prevention. It is probable that seeming disagreement as to the relationship of ammonia to taste may be explained by the difference in contained and added ammonia. In some waters, particularly well supplies, markedly susceptible taste conditions exist. Adams showed that in the well water under examination 1 part of phenol in 2 000 million parts of water upon chlorination produced a taste which could be readily detected. Doctors Thresh and Beale,[15] in England, further showed that one observer was able to detect taste in a chlorinated water when only 1 in 5 000 million parts of phenol was present. These figures show very conclusively the super-

sensitive taste possessed by some observers and emphasize the difficulty of treating susceptible supplies.

Taste in chlorinated water caused in part by excessive or decomposing organic matter, has received a great deal of attention and is possibly one of the most expensive and difficult conditions to treat. W. Donaldson[10] points out that the term "organic matter" as applied to water is a very broad term which includes many substances of whose nature we have little specific knowledge, and at present little means of differentiating by laboratory tests. One of the earliest cases was reported in 1915 by Letton[16] at Trenton, N. J., where the water was high in organic matter and free of residual chlorine, yet a pronounced chemical taste was present. He concluded "that the taste and odor was due to some complex chemical change brought about by the action of the chlorine on the organic matter present in water." G. E. Willcomb[17] in describing the Albany water, pointed out that during periods of excessive organic matter there was a tendency for the chlorine to become absorbed and rendered inert. At such times a peculiar taste was apparent that somewhat resembled phenol and was caused by the formation of oxychlorides. Practically all observers who have studied taste conditions in waters high in organic matter record an increase in oxygen absorbed and a decrease in oxygen dissolved. F. H. Waring,[18] who made some exhaustive investigations in Ohio, considered the decrease of the dissolved oxygen constituent as the most important single factor entering into the intensity of earthy tastes and odors, and that if a deficiency of oxygen existed, the oxidation of the organic matter would take place at the expense of reducing certain substances causing taste and odor, which represented the products of decomposition. In view of the fact that exception is frequently taken to the expense involved in the treatment and prevention of taste, Waring's comment is worthy of mention. He stated, "that additional expense is warranted for the removal of tastes and odors of the class mentioned in order to prevent suspicion as to the sanitary quality of the water from entering the minds of the water users." The types of taste resulting from high organic matter have been described as strong grassy, medicinal, earthy, mouldy, and musty.

The most difficult class of water to treat is that containing taste-producing substances of unknown origin, which become intensified upon the addition of a small amount of chlorine. They can be said to include three types of water, all of which are normally of great organic purity and usually free from or low in color. The sources are well supplies, waters from natural catchment areas, and the waters of the Great Lakes of America. Chlorination is often practiced on these supplies for minor surface-water pollutions, as a factor of safety when the supplies are unfiltered, or as a final adjunct in the purification process. Numerous theories have been advanced as to the cause of taste. Some of these have been supported by laboratory observations but, in the absence of conclusive proof, they must be regarded as plausible hypotheses. Regarding the well supplies the results are very

TABLE 1.

TASTE AND ODOR PRODUCED ON ADDITION OF CHLORINE TO WATER CONTAINING VARIOUS AMOUNTS OF SODIUM IODIDE.

Sodium iodide added, p.p.m.	Chlorine dosage, p.p.m.	TASTE AND ODOR AFTER ADDITION OF CHLORINE.						
		1 hour.	2 hours.	3 hours.	4 hours.	5 hours.	6 hours.	24 hours.
0.01	0.23	None	None	None	?Tr. I	Tr. I	Tr. I	Tr. I
0.025	0.23	None	None	?Tr. I	Tr. I	Tr. I	Tr. I	Tr. I
0.05	0.23	None	Tr. I	Tr. I	I	I	I	Tr. I
0.1	0.23	None	I	I	I	I	I	Tr. I
0.15	0.23	Tr. I	I	I	I	I	I	Tr. I
0.2	0.23	I	I	I	I	I	I	Tr. I

Note. The odor of iodoform was more marked than the taste in these samples.

puzzling. Adams has shown that atmospheric phenol may be a factor, but he stated that "taste will not occur if the chlorinated water is not exposed to air." It should be pointed out that many large well supplies are pumped directly into the mains, and between the time of their discharge and chlorination no exposure to the air occurs, yet marked tastes occasionally develop when only minute quantities of chlorine are applied. It is difficult to overlook the possibility of phenol contamination of other than atmospheric origin. The probability of atmospheric contamination would seem far more likely in water drawn from mountain areas flowing through long aqueducts or open channels, particularly when such supplies pass through mining areas. This would largely apply to water low in organic matter, similar to that in Salt Lake City where considerable taste troubles were reported on applied chlorine doses as low as 0.125 p.p.m. There is again the possibility of natural iodides being in part responsible for the production of taste. Adams[19] considered that natural waters may have the necessary organic compound set free from organic matter by bacterial action and the iodine might be set free from its compound by chlorine. We have found in Toronto, that sodium iodide, which is being used in some cities for the prophylactic treatment of goiter, will cause an iodoform taste in chlorinated water when present in quantities as low as 0.010 p.p.m., equivalent to 10 parts per billion. At Rochester[20] B. C. Little reported over 40 parts per billion of iodine as having been recovered from the iodized supply. In our experiments, described in Table 1, taste and odor remained in the water 24 hours after application of the sodium iodide and chlorine, the taste being less pronounced than the odor, yet no unusual taste conditions have been reported at Rochester or Minneapolis following the treatment of their supplies. Wide variations in the organic and mineral content do not allow comparisons of various water supplies to be made, particularly as to liability to taste; neither can the susceptibility be gaged or explained in the light of current knowledge. Throughout the world, except in instances where known sources of taste exist, taste appears to be periodic. There are certain seasons of the year when it is more intensive, the least being reported during the warm summer months. In describing the occasional taste following chlorination in the London, England, supply, Sir A. C. Houston[21] has refrained from expressing himself as to the possible cause. Seemingly he has not yet satisfied himself that the tastes which have occurred in the London water in the past are the result of the formation of chloro-phenols. The waters of the Great Lakes of America are very susceptible to taste. Normally they are free from color, low in organic matter, and comparatively hard. It is probable that local contamination is the predominating cause of taste troubles in these supplies. Many instances could be mentioned of supplies which occasionally develop taste without any clearly defined reason.

Toronto Experiments.

Experimental work has been carried out in the Toronto Filtration Plant Laboratory during the past ten years, to determine the cause of taste, but to date it cannot be said that actual proof is available as to its origin. The supply is drawn from Lake Ontario and is filtered through slow sand and mechanical plants. The slow sand filter effluent is much the least prone to taste. Many observations have indicated that the taste is brought about by a combination of conditions. The most intensive taste periods are always accompanied by excessive bacterial pollution, high free ammonia, and increased organic matter. Flood water high in organic matter and comparatively free from excremental pollution does not cause taste following chlorination. The most severe taste periods have occurred in the months of March, April, August, September, October, and November. In the months of January, February, June, and July taste has been rare, yet the discharges of sewage and industrial wastes are constant all the year round. Numerous sources of pollution have been investigated, with indefinite results. The taste periods of the longest duration usually follow severe storms on the lake, sometimes lasting three or four days. The stirring-up of the organic matter appears to be in part responsible, yet at times of calm weather pronounced taste has occurred. During these calm periods the excessive pollution of the water indicates the presence of sewage into which the industrial wastes of Toronto are directly or indirectly discharged. We have been forced to the opinion that at such times phenoloid substances were responsible, occurring either in the industrial waste discharges or resulting from decomposition of putrescible matter. The estimation of small amounts of phenol in water is difficult and the results so unreliable that we have been compelled to confine our observations to actual taste-tests, which have seldom failed. During the past two years over 2 000

TABLE 2.

Taste produced on Addition of Various Amounts of Chlorine to Unchlorinated Toronto Water during Period When City Supply Tasted, Following Chlorination.

Chlorine dosage, p.p.m.	Taste and odor. Before de-chlorination.	After de-chlorination
0.19	Doubtful	
0.29	Trace of iodoform	
0.39	Faint iodoform	Iodoform
0.48	Very strong iodoform	Strong iodoform
0.58	Iodoform	Iodoform
0.68	Trace of iodoform	Trace of iodoform
0.77	Strong chlorinous	None
0.87	Strong chlorinous	None
0.97	Strong chlorinous	None
1.06	Strong chlorinous	None
1.16	Strong chlorinous	None
1.26	Strong chlorinous	None

		Naphthenoid	Benzenoid							Naphthalenoid	Heterocyclic
Un-substituted		(Cyclohexane)	Benzene			Toluene		(Cymene)	Xylene	(Naphthalene)	Pyridine
Mono-substituted	OH	Cyclohexanol	Phenol			o-Cresol m-Cresol p-Cresol	Benzyl Alcohol	Thymol	P-Xylenol	α-Naphthol	
	NH_2			Aniline							
	OCH_3				Anisole						
Di-substituted	OH, OH		Catechol Resorcinol Hydroquinone								
	OH, OCH_3		Guaiacol								
	OH, NO and OH, NO_2		o-Nitrophenol m-Nitrophenol p-Nitrophenol							α-Nitroso-β-Naphthol	
	OH, NH_2		p-Aminophenol								
Tri-substituted	OH, OH, OH		Phloroglucinol Pyrogallic Acid								
	CH_3O, CHO, OH		Vanillin								

FIG. 1. Substances derived from the products of the destructive distillation of coal showing those which do not cause taste and those capable of producing taste and odor in the presence of free chlorine. The heavy lines indicate the substances producing the medicinal or iodoform taste. The light lines show the presence of a chemical taste peculiar to the particular compound used which is not greatly altered by moderate doses of free chlorine. These tests were made on solutions containing 0.10 part per million of the substances to which was added 0.25 part of chlorine.

experiments have been made. In the Toronto water the critical taste-producing dose of chlorine is generally between 0.25 and 0.45 p.p.m. Taste is usually intensified by slightly increasing the application of chlorine above the taste-producing dose, as shown in Table 2. Above certain figures the taste disappears, leaving a chlorinous taste and odor.

In order to ascertain what were the substances derived from the destructive distillation of coal which produced a taste in chlorinated water, a study was made of a large grouping, which is shown in Fig. 1. We were able to show that the taste-producing substances were practically confined to the mono-substitution groups. Phenol, ortho-, meta- and para-cresol, xylenol, and anisole caused the characteristic iodoform taste in chlorinated water, varying in intensity. The taste caused by phenol was more pronounced and lasting than with any other group. Of the cresol group which produced marked odor as well as taste, ortho produced a more marked taste than meta. The para-cresol caused a foul iodoform odor but the taste was much less pronounced than with either of the other two and was easier to destroy with excess chlorine. Xylenol caused a very strong iodoform taste and odor while anisole caused marked taste and odor. Thymol retained its characteristic properties which were not affected by small doses of chlorine but were somewhat broken down by large doses. Guaiacol caused a decided chemical taste and odor which is distinctive from that produced by phenol or cresol. The distinctive chemical taste produced by thymol and guaiacol and one or two of the others, although to a much lesser degree, was greatly decreased by excessive doses of chlorine. As it is improbable that such refined substances would be discharged except by accident, their connection with taste production need not be considered.

The determination of phenols in the raw water by the distillation method was carried out for two years and actually showed a slight increase during susceptible taste periods, but we have not found the test sufficiently sensitive to use as an index to phenol pollution. The test is of greater value in determining the presence of considerable quantities of phenol. In examining some industrial discharges of unknown origin, we found that the distillation test, as judged by the reactions, showed the presence of large quantities of phenol. The distillates were treated with various doses of chlorine but failed to produce taste, indicating that some other substance or substances reacted colorimetrically in the same manner as phenol. In connection with the determination of phenols, particularly in water, reference should be made to the work of R. Chapin,[22] J. J. Fox and J. H. Gauge,[23] R. D. Scott,[24] and R. D. Scott, W. Donaldson, and C. E. Trowbridge,[25] who have described various methods for its detection.

W. Donaldson[10] has stated that the different color reactions varying from blue to green, when using the Folin-Dennis reagent, were not without value in distinguishing phenol from some of its homologues, but our work in Toronto has not demonstrated the color reactions to be of practical value. We examined some 28 substances derived from coal-tar products

and, beyond demonstrating a difference in intensity of color, were not able to distinguish between the phenol or cresol group nor between the taste- and non-taste-producing substances. The colors changed upon standing and our readings were taken at the end of 10 minutes, 2 and 18 hour periods. The most intense blue color was produced by aniline and the cresol group, particularly ortho-cresol; a medium blue occurred with thymol; and blue of varying intensities with phenol and the other groupings. The only distinctive colors were produced by o-nitrophenol and xylene, the former being a pale green and the latter a blue green. These color reactions were determined on solutions containing 0.020 p.p.m. of the substances and were examined both by the direct method and after distillation. Similar observations were made using the Fox and Gauge reagents, with the same results. The ability of so many other substances to respond to color changes in the presence of each of the indicators used, would seem to limit the value of the colorimetric test.

Having demonstrated the chief taste-producing substances and studied the effect of various doses of chlorine on them, further experiments were carried out on the Toronto water under varying conditions of pollution. These tests showed the value of increasing doses of chlorine and were so encouraging that it was decided to try the excess chlorine method as suggested by Sir. A. C. Houston,[14] who was the first to demonstrate its effectiveness on the London supply. As was previously mentioned, the London water was treated for taste removal and prevention when dealing with a taste of unknown origin. The excess chlorine and de-chlorination method is able to destroy taste in many instances, regardless of the condition causing it. The treatment consists of adding chlorine considerably in excess of the normal dose required, which is frequently three or four times above the usual figure, and of removing the excess chlorine after a suitable contact period, by means of a de-chlorinating reagent. For the latter purpose sulphur dioxide was used. The application of large doses of chlorine appears to break down or prevent the formation of substitution compounds which are liable to occur in water containing small amounts of chlorine and phenol. The taste of free chlorine is not offensive and can be removed by any of the recognized dechlors. A great deal of experimental work was undertaken to determine the optimum doses of chlorine and sulphur dioxide necessary. Variations in the water temperature and rapid changes in quality of the water made the work slow and arduous. Both of these conditions affected the rate of chlorine absorption. During some periods when the water developed taste 0.75 part per million completely destroyed it, while at other times, under seemingly comparable conditions, as much as 1.25 parts were required. As a result of a large number of observations we are of the opinion the 1.0 part per million will usually suffice. It was found that the filtered water from the slow sand plant required considerably less chlorine than the effluent from the mechanical filters. In 1922, N. J. Howard reported that the slow sand system showed a higher removal of

phenol and greater purification than occurred in the mechanical filters, and it seems probable that this condition is one of the reasons why less chlorine is required to effectively super-chlorinate the slow sand filtered water. When it was found that the maximum dose necessary for Lake Ontario water was 1.25 parts per million, further observations were made and conflicting results encountered. Water containing phenol was treated with large doses of chlorine and de-chlorinated without removal of taste (Table 3). On one occasion the control samples of a series which had pro-

TABLE 3.

EFFECT OF VARIOUS DOSES OF CHLORINE WITH SHORT CONTACT PERIOD, SHOWING INCREASED INTENSITY OF TASTE AND ODOR WITH THE HIGHER AMOUNTS OF CHLORINE UNDER THESE CONDITIONS.

Phenol added to sample, p.p.m.	Chlorine dosage, p.p.m.	Period of Contact allowed before de-chlorination, minutes.	Taste and odor after de-chlorination.
0.011	0.25	10	Very slight iodoform
0.011	0.5	10	Strong iodoform
0.011	0.75	10	Very strong iodoform
0.011	1.0	10	Very strong iodoform
0.011	1.25	10	Very strong iodoform

duced taste but which had not been de-chlorinated were tasted some 18 hours later, when it was found that the water was free from taste but contained a trace of chlorine. De-chlorination followed and a completely tasteless water resulted. This indicated the necessity of time observations, which finally solved the problem. We found that there was a definite amount of chlorine and time contact necessary to effectively destroy taste, and that large amounts of chlorine with short contact periods were ineffective. A point of very considerable importance is that the time contact can be materially lessened by increasing the dose of chlorine. Briefly, our results showed that when dealing with Lake Ontario water to which specific substances had been added, the contact period was dependent upon the amount of taste-producing substance present. The phenol group at all times requires longer contact than the cresols. As the amount of taste-producing substances increase, so must the necessary contact period be lengthened, as is shown in Table 4 and Fig. 2, which is a brief summary of several hundred tests. The outcome of our work was the recommendation that the new process be tested out on a practical scale. This was finally approved by the Board of Control. The treatment was commenced on September 2 and continued until September 12, 1926. During this period over 70 million gal. were treated daily, the chlorine dosage ranging between 6 and 10 pounds per million Imp. gal. of water. The dose of sulphur dioxide varied between 0.275 and 0.625 part, equivalent to 2.75 and 6.25 pounds per million gal., respectively. The super-chlorination treatment was undertaken during a severe storm period lasting $4\frac{1}{2}$ days, during which

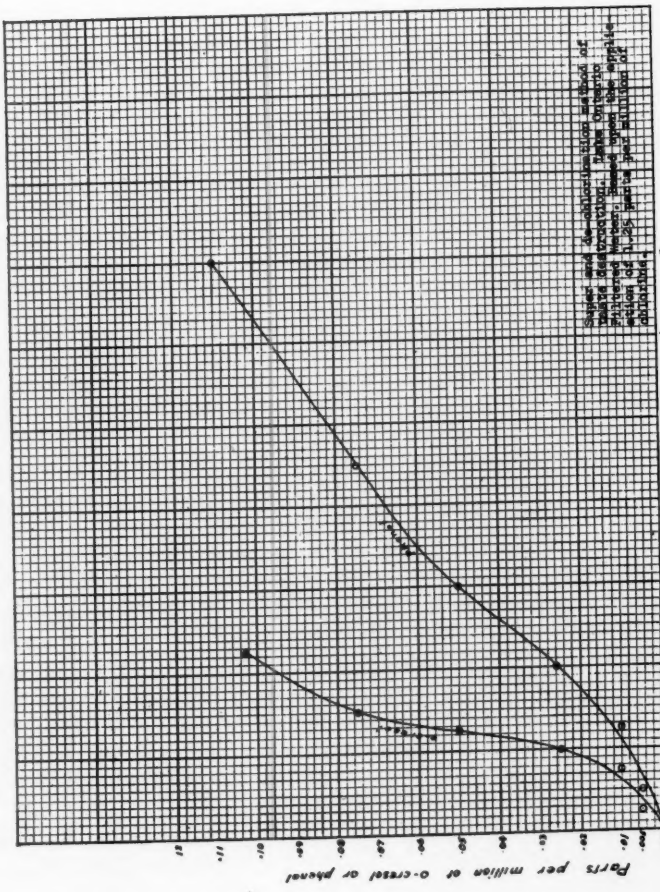
Super and De-chlorination method of taste destruction. Lake Ontario Filtered water. Based upon the application of 1.35 parts per million of chlorine.
Parts per million of o-cresol or phenol
Hours of contact necessary to destroy taste

FIG. 2. SHOWING TIME FACTOR INVOLVED IN SUPER- AND DE-CHLORINATION METHOD OF TASTE DESTRUCTION.

TABLE 4.

SUPER- AND DE-CHLORINATION METHOD OF TASTE DESTRUCTION — LAKE ONTARIO WATER.

Series No. 1.

Concentration of taste-producing substance, p.p.m.	Chlorine dosage, p.p.m.	Sulphur dioxide dosage, p.p.m.	Hours of contact necessary to destroy taste.
Phenol.			
0.005	1.25	1.0±	½
0.01	1.25	1.0±	1¼
0.027	1.25	1.0±	2
0.05	1.25	1.0±	3
0.074	1.25	1.0±	4½
0.111	1.25	1.0±	7
o-Cresol.			
0.005	1.25	1.0±	¼
0.01	1.25	1.0±	¾
0.026	1.25	1.0±	1
0.05	1.25	1.0±	1¼
0.074	1.25	1.0±	1½
0.103	1.25	1.0±	2¼

Series No. 2. Showing Decrease in the Time of Contact Necessary When Chlorine Dosage is Doubled.

Phenol.			
0.05	2.5	2.+	½
0.1	2.5	2.+	2
0.2	2.5	2.+	3

period the island water supply remained untreated by the new process. Taste developed in the island water and became very pronounced, resulting in complaints. The treatment of the city water was completely and uniformly successful, not a single taste complaint being received. The water was bright and free from all taste and odor. The island water, acting as a control, indicated that had the city supply been treated in the usual manner with approximately 0.275 part of chlorine, taste would have been general throughout the city. During the treatment the chlorine was applied through four temporarily equipped compensator type machines. The contact period varied between one and 1½ hours, and the sulphur dioxide was applied through specially calibrated vacuum pedestal type machines. The maximum amount of chlorine applied on any one day was approximately 650 lbs., while some 350 lbs. of sulphur were used. The estimated cost of the new treatment for continuous application is approximately $32 000 yearly, while intermittent application would cost about $21 000. The future policy of the city has yet to be defined. It is very doubtful if the intermittent treatment would avoid an occasional taste from developing, as it is extremely difficult under our operating conditions, which are yearly becoming worse, to determine when taste will occur. Having successfully

demonstrated the treatment in Toronto, it is expected that the new process will be continuously applied.

As might be expected, some minor difficulties were encountered in starting the new treatment. It was found that under heavy discharge conditions the sulphur dioxide cylinder pressure was difficult to maintain. It was necessary to apply continuous heat and maintain a room temperature in excess of 80° F. in order to keep the pressure at a minimum of 10 lbs. No difficulty was experienced under low discharge conditions, equivalent to 50 per cent. of the capacity of the machines. The other point noticed was the necessary application of greater amounts of sulphur dioxide than was theoretically necessary to combine with the chlorine, which is 32 lbs. of sulphur dioxide to 35.5 of chlorine, or a ratio of 0.90 to 1.0. This may be explained by the partial oxidation of the sulphurous acid by the dissolved oxygen in the water, the resulting sulphuric acid combining with the alkalinity without affecting the free chlorine. When sulphur dioxide is dissolved in water the following chemical reaction is involved: $H_2O+SO_2=H_2SO_3$. The sulphurous acid in the presence of chlorine is oxidized to sulphuric acid, the chlorine combining with the hydrogen of the water molecule involved in the reaction to form hydrochloric acid as expressed in the following formula: $H_2O+Cl_2+H_2SO_3=2HCl+H_2SO_4$. Both the chlorine and the sulphur dioxide are thus converted into the corresponding acids, which combine with the normal alkalinity of the water, resulting in a slight increase in the non-carbonate hardness, consisting of calcium chloride and calcium sulphate, and free carbonic acid and a corresponding decrease in the carbonate hardness expressed in the following formulas:

$$Ca(HCO_3)_2+2HCl=CaCl_2+2H_2O+2CO_2$$
$$Ca(HCO_3)_2+H_2SO_4=CaSO_4+2H_2O+2CO_2$$

Expressed in terms of calcium carbonate, the increase in permanent and the decrease in carbonate hardness is equal to 1.41 p.p.m. for each part of chlorine added, assuming that all chlorine combines with the alkalinity, and 1.56 parts for every part of sulphur dioxide. The free CO_2 increase in each case is 1.24 and 1.375 parts per million, respectively. No objection can be made to the slight change in the hardness of the water, if it is borne in mind that 1 grain per imperial gal. of applied alumina sulphate, commonly used in filtration, would increase the permanent hardness 6.785 parts per million, which is approximately twice as much as would result from the application of one part per million of chlorine and sulphur dioxide, respectively. The ratio of free carbonic acid production is approximately the same in each case. It will be noted that the total hardness remains the same.

In Table 5 is shown the relationship between the amount of residual chlorine and the amount of sulphur dioxide added. In actual practice Sir A. C. Houston has advised the application of a slight excess of sulphur dioxide, and we have found during the new treatment in Toronto that it

TABLE 5.

DE-CHLORINATION EXPERIMENTS, SHOWING RELATIONSHIP BETWEEN FREE CHLORINE CONTENT AND DOSAGE OF SULPHUR DIOXIDE REQUIRED.

Free chlorine content of sample, p.p.m.	Sulphur dioxide added, p.p.m.	Chlorine equivalent of sulphur dioxide added, p.p.m.	Residual chlorine, p.p.m.	Temperature, deg. Fahr.
0.49	0.44	0.49	0.12	60
0.48	0.41	0.46	0.12	60
0.40	0.35	0.39	0.10	60
0.36	0.32	0.36	0.05	60
0.06	0.055	0.06	0.025	60

was necessary to apply as much as 25 per cent. in excess of the theoretical dose to complete the removal. If the super-dose of chlorine has already removed the taste, it would seem more economical to leave a very slight residual chlorine in the water after treatment, thus guarding against an overdose of sulphur dioxide which is approximately twice as expensive as chlorine. Slightly overdosing with sulphur dioxide or a slight residual free chlorine are unimportant, however.

Regarding the dilution of treated with untreated water, we have found it an unreliable method of reducing taste, particularly if the treated water contains any residual chlorine. We have observed that in a susceptible water a dose of chlorine below the normal requirements will cause taste. The addition of super-chlorinated water which had not been de-chlorinated, and which contained 25 per cent. of the original dose after 30 minutes contact, to an equal volume of unchlorinated filtered water, produced an iodoform taste. Experiments showed that the amount of chlorine in the treated water was just sufficient to cause taste in the whole supply when diluted.

Brief experiments were made to determine the relationship of hydrogen ion concentration to taste production and treatment. This was suggested by L. H. Enslow when visiting the Toronto laboratories. On numerous occasions it was observed that when distilled water containing phenols was treated with chlorine the characteristic chloro-phenol taste was not produced. While these results were uniformly negative in Toronto, it is understood that similar results were not obtained in Toledo. Several series of experiments were carried out in Toronto to determine if the failure of taste to develop was due to the low pH value of distilled water, usually in the neighborhood of 6, or to the absence of mineral and organic matter. The pH theory appeared to be confirmed by the fact that with filtered water to which 0.010 p.p.m. of phenol had been applied and the pH adjusted to 5.8 with sulphuric acid, no taste developed when 0.25 part of chlorine was added, whereas the same sample at the normal pH of 7.7 tasted badly of iodoform. The above series of experiments were carried out to determine whether an optimum pH value for the production of taste

existed. The buffer salts employed, particularly the phosphate, interfered and the taste of these mixtures somewhat masked the chloro-phenol taste. This interference is evident in samples having pH values of 7.5 and 8.0 at which points both phosphate and boric acid mixtures were employed, the taste in the presence of the latter being many times stronger than at similar pH values in the presence of the former. It is obvious that the salts present influence the production of taste as well as the H-ion concentration. The sample which had been adjusted with sulphuric acid when restored to its original pH value remained tasteless. This point may be of importance in the treatment of waters of low pH value in which alkali is employed for lessening corrosiveness. In such cases the application of chlorine prior to increasing the pH value may be a means of avoiding taste troubles.

Determination of Free Chlorine by the o-Tolidin Method.

Recently we had occasion to carry out a large number of free chlorine determinations by the o-tolidin method under field conditions. Very erratic results were obtained, which were difficult to interpret, and it became evident that there was an interfering element in the technique employed. This interference was later traced to exposure of the sample, immediately after addition of the reagent, to direct sunlight. In order to determine the extent to which exposure to sunlight depresses the formation of the o-tolidin-chlorine color a series of 16 sets of duplicate samples of freshly chlorinated water was collected over a period of several days and examined for free chlorine, the first sample of each set being allowed to stand 5 minutes in the dark after addition of the reagent, and the second 5 minutes exposed to direct sunlight. The average indicated chlorine content under each condition was as follows:

Light conditions.	Number of samples.	Indicated chlorine content.		
		Average.	Maximum.	Minimum.
Darkness	16	0.134	0.15	0.11
Sunlight	16	0.043	0.055	0.035

The interference is in direct relation to the intensity of the sunlight, a sample exposed to sunlight in late afternoon reading 0.08 compared with 0.125 for a duplicate sample protected from light. Exposure to sunlight after development of color has similar effect. In one instance the indicated chlorine content of a sample immediately after the addition of o-tolidin, was 0.135, while after standing 5 minutes in sunlight it was only 0.04. Artificial (electric) light does not appear to influence the depth of color produced. The remarkable sensitiveness of the color to light is demonstrated by the results of the following experiment, in which quadruplicate samples were exposed under varying conditions, including light, darkness, shadow in the laboratory, sunlight in the laboratory, and sunlight in the open air.

Light conditions.	Indicated free chlorine content.
Darkness	0.08
Laboratory, in shadow	0.075
Laboratory, in sunlight	0.05
Open air, in sunlight	0.025

It is evident that the light conditions must be carefully controlled if accurate results are to be obtained with the o-tolidin method. That the effect is due to interference with color production, and not to increased rate of chlorine absorption by water in sunlight, is shown by the following experiments, in which duplicate samples were allowed to stand protected from the light and in the direct sunlight, respectively, for 5 minutes, the reagent being then added and the tubes allowed to stand an additional 5 minutes protected from the light. A slightly increased rate of absorption only is evident.

	Indicated free chlorine content.	
	Protected from light.	Direct sunlight.
Set No. 1	0.12—	0.11
Set No. 2	0.125	0.12

Summarizing our work on taste destruction by the super- and de-chlorination method at Toronto, we have endeavored to show:

1. At Toronto, while phenol is contributory to the production of taste, there are also other causes of unknown origin.

2. In many instances, taste is directly attributable to the production of substitution compounds formed in chlorinated water by the phenol and cresol groups.

3. Decomposing organic matter may form phenoloid bodies and cause taste in chlorinated water.

4. Of a large group of substances examined derived from the destructive distillation of coal; phenol, cresol, anisole and xylenol will produce an iodoform taste and odor in the presence of free chlorine.

5. Thymol and guaiacol in chlorinated water retain certain chemical characteristics but do not produce the iodoform taste or odor. These tastes can be partly broken down by excessive doses of chlorine.

6. The colorimetric test, using the Folin-Dennis reagent as a means of identifying taste-producing substances, is of limited value.

7. The formation of chloro-phenol substitution compounds in chlorinated water can be prevented by the excess chlorine and de-chlorination method.

8. Definite time contact periods are necessary for varying doses of taste-producing substances to effect their destruction.

9. The contact period can be shortened by greatly increasing the chlorine dosage.

10. Under heavy discharge conditions sulphur dioxide requires considerably more heat than chlorine to maintain cylinder pressure.

11. A definite excess of sulphur dioxide is necessary to remove all traces of residual chlorine.

12. Overdosing with sulphur dioxide can be prevented by leaving a faint trace of chlorine in the treated water.

13. Technical supervision is essential for the effective and economical operation of the super- and de-chlorination treatment.

14. Taste may be influenced by the H-ion concentration of the water. Acid and highly alkaline water are the least liable to taste.

15. Estimation of residual chlorine by the o-tolidin method should not be made in sunlight, which interferes with color production but not to any great extent with rate of chlorine absorption by the water.

Where taste conditions are either periodic or frequent the super- and de-chlorination system should be tried. It may be argued, that the most logical action is to stop the source of taste causation rather than spend money on treatment. This is fundamentally true where it is possible, and D. M. Watt[26] has recently shown what was done in the State of Pennsylvania, where a remarkable clean-up of river pollutions was made. There are, however, many more cases of taste in water supplies of unknown than of known origin. Where known sources exist it may be possible to compel the offending industries to abate the nuisance either by coöperation or litigation. Whether the cause of taste is of known or unknown origin the super- and de-chlorination method offers a remedy at a cost which cannot be regarded as prohibitive. The practical treatment of waters heavily polluted by industrial wastes, and containing large amounts of phenols and cresols, may be doubtful. Two recent instances of particular interest can be mentioned. Both of these supplies involve difficult treatment. Paul Hansen[12] reported that the excess chlorine method was effective in destroying taste in the heavily polluted waters at Marquette, but that the treatment was too costly to consider. On the other hand, super-chlorination at Ironton, O.,[27] was reported to be a failure. At Ironton the Ohio River water containing large amounts of industrial wastes and excessively polluted, was super-chlorinated with 20 lbs. per million gal. and received 12–24 hours' contact before de-chlorination. The matter of chlorine dosage is one that must be determined on the particular water involved. In Toronto it was found that conditions were favorable for a 1 to 1½-hour contact period with a dose not exceeding 1.25 parts per million. If it is impossible to give the predetermined contact period, the success of the treatment is doubtful, unless it can be shown that greatly increased doses of chlorine with shorter contact will accomplish the desired result. Under these conditions the question becomes a matter of cost. We found in Toronto that the post-chlorination process was more effective than the pre-chlorination treatment when applying excess chlorine. In water heavily polluted, there are probably many other substances which act on chlorine and interfere with its oxidizing properties. The removal of these substances by coagulation and filtration allows the chlorine to act more

directly on the phenoloid substances. In all our work we have failed to find any taste-producing substance derived from the destructive distillation of coal, which did not respond to the excess chlorine treatment.

The authors wish to gratefully acknowledge the advice and assistance given by Frank Hannan, Chemist at the plant; also the assistance rendered by the laboratory staff, without which the work could not have been successfully carried out. Messrs. A. U. Sanderson, Superintendent, and L. Allan, Assistant Superintendent, of the Filtration Plant, coöperated throughout the successful application of the new treatment.

In conclusion, the writers are particularly anxious of paying tribute to Sir Alexander Houston, Director of Water Examination, Metropolitan Water Board, London, England, whose active researches during many years past have not only been of absorbing interest, but have been materially responsible for the research work which led to the successful treatment of the Toronto water. Information contained in the unique reports on water purification, issued by the Metropolitan Water Board, have on more than one occasion been of value in solving numerous problems encountered in all parts of the world.

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SOME RANDOM NOTES ON WATER-WORKS PRACTICE ABROAD.

BY CHARLES W. SHERMAN.*

[*Read September 15, 1926.*]

The following comments are based upon observations made in England, France, Belgium, and Holland during a brief visit in the summer of 1926. Some specific information was obtained from the engineers of the Metropolitan Water Board of London, of the water works of the city of The Hague, and of the North Holland Water Supply District; also from the Stanton Iron Works Company in England and the Pont-à-Mousson foundry in France. Some information has also been obtained from English, French, and Dutch publications; but many of the notes are based upon such observations as it was possible to make in the streets while sight-seeing or strolling about.

The American water works man notices at once that fire hydrants of the post type are conspicuous by their absence, except in a few localities and, when found, they differ considerably from ours. Indeed, the only post hydrants which I saw were in a suburban part of Amsterdam, and they looked as though the barrel did not exceed 3 in. in diameter. In general, there are no posts along the curb, except where lamp or trolley poles are so located.

In some places, as in Paris, he may find frequent street-washing outlets at the curb; here there is a secondary supply of river water used solely for washing streets and flushing sewers. Bubbling fountains or other drinking fountains, such as we are accustomed to, are absent; but in residential districts, particularly in the smaller towns, fountains are provided at the curb or building line (Fig. 1), to which people may come to fill their pails or pitchers (the inference is that an appreciable part of the population have no water supply except such as they carry from such public fountains). A row of gate boxes may be noted, indicating the service shut-offs, either in the street or the sidewalk; and after some search the comparatively small rectangular or elliptical covers of the hydrant boxes may be discovered, usually with enameled plates upon the adjoining buildings to indicate their location. In Paris, and to a lesser degree in London, it is difficult to find any surface indications of the main pipes, which are located in the sewers or other subways or conduits.

Consumption ranges from 15 to 35 U. S. gal. per head daily. This low consumption is due to various causes, among which the most important are:

Comparative difficulty of using water. Drinking of water is not common and it is not always easy to get a drink of water even with meals.

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Bathrooms are much less common than with us; even in hotels, rooms with private baths are somewhat uncommon. Laundry is commonly done directly in streams or canals; set tubs are infrequent. Fire demands are comparatively small, which means smaller street mains and, consequently, much less length of joints to leak. Pressures in many cases are low, so that leaky fixtures and joints do not lose very much water. In British practice houses are generally provided with storage tanks controlled by ball cocks, from which the entire domestic supply is taken, except water for drinking. Very little water is furnished for manufacturing or industrial uses from the public supply, such requirements being met by private installations.

Pressures. In the large cities water is furnished under pressures comparable to those generally provided in our American cities. In London,

FIG. 1. DRINKING FOUNTAIN, NANCY, FRANCE.

for instance, there are several pressure zones, in each of which the normal pressure ranges approximately from 35 to 70 lbs., depending upon elevation.

Service reservoirs or elevated tanks are so located as to maintain suitable service in these districts, but if, as in England, all domestic supply is furnished through the medium of house tanks, the pressure at fixtures is bound to be slight, no matter what the pressure on the main pipes. Standpipes, as known to us, are non-existent there. The term "standpipe" is restricted to its original meaning, namely, a riser pipe and overflow for regulation of pressure. In some places, for instance, in some small districts of London, like Hampstead Heath, standpipes (Fig. 2) are provided and the pump pressure is raised to that corresponding to the standpipe, perhaps two or three times a day, to fill the house tanks; at other times the pressure on the mains is insufficient to raise water above the ground floors. In many of the small cities, however, the water supply is under very slight

pressure, sometimes only enough to flow feebly from fixtures on the ground floors of houses. In general, at least on the Continent, people are accustomed to having but slight pressure available* and, partly because so much time is required to draw any considerable quantity of water, partly because much of it has to be carried in pails or pitchers, they get along with as little as possible. Letting water run to get a cool drink is not done.

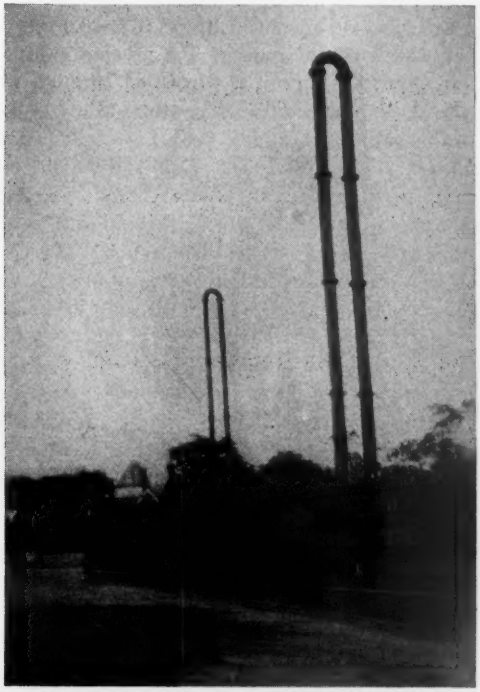

FIG. 2. STANDPIPES AT HAMPSTEAD HEATH, LONDON, ENGLAND.

Habits of economy in water, as in many other things, seem to be well established among most Europeans. But if we lived under similar conditions we would be likely to practise similar economies.

In some cases, also, the available supply of water is so limited that without such economy it would be impossible to get along. I shall recur to this subject later.

Main Pipes. Cast iron is almost universally employed, although in some places, notably the coal-mining districts of Wales, where settlements are frequent, steel pipe is used. Appreciable amounts of centrifugally cast

*A standard French textbook states that "satisfactory service requires at least 1 meter pressure at the highest fixtures."

pipe are in use in London, in sizes 12 in. and smaller. I did not learn of any other uses of centrifugally cast pipe.

A pipe made centrifugally of asbestos and Portland cement is being made in Italy and is used there, to a considerable extent, for water mains. It is stated that this pipe can be had of ample strength; that it is readily cut, and that it does not deteriorate or lose capacity with age. I did not see any of this pipe, or anyone who had actually used it, but met some engineers who had investigated it and were considerably impressed by it.

Pipe Sizes are much less than in America, because fire demands are so much less, as well as on account of the much smaller consumption. Moreover, where domestic supply is furnished through the medium of house tanks, the daily fluctuation of consumption disappears in large measure, — in other words, the daily peak is but little higher than the average consumption. In London the smaller pipes in the network are commonly 4 in. in diameter, often 1 000 ft. or more in length, and in smaller places 3 in. is a common minimum size. In London they consider a 4-in. pipe as ample to furnish the supply to a fire hydrant.

It seems strange to an American to note the use of what we should consider odd sizes of pipe, — 5-in., 7-in. and 9-in. especially. They are, however, rather common in British practice.

Pipe Patterns are not standardized abroad to the same extent as with us. There is a so-called British standard, adopted some 15 years ago by the British Engineering Standards Association, but it is not universally accepted, and a committee is now at work with the idea of modifying the standard. The London Metropolitan Water Board has never adopted the British standard, but continues to use its own designs, the most marked difference being a plain spigot instead of one with a bead. In France the specifications of the city of Paris are adopted with practical uniformity. Belgium and Holland use French, German, or British pipes as they can buy to best advantage. The French pattern has a heavy bead on the spigot and the lead groove in the bell is small and semi-circular, and the bell itself is funnel-shaped, i. e., it has no shoulder. The German pattern has plain spigots.

The French are using some cast-iron pipe with steel bands shrunk on, 5 or 6 of such bands in a 4-meter length of pipe. The object is twofold: first, to enable the use of a thin and lighter pipe without loss of strength; second, to insure against large loss of water and consequent damage to streets in case of breakage, since tests have indicated that the extent of the damage to such a pipe is a crack extending from one band to the next, never a burst pipe. The Pont-à-Mousson foundry has made many tests and has sold a considerable amount of this pipe, particularly to the city of Paris. The claims for it appear to be well founded, but an American engineer cannot but wonder how long the steel bands would last if buried in the earth here, — in other words, to question the permanency of the reinforcement, although European experiences with bolted saddles and the like seem to indicate a very long life for steel bands or bolts.

Corrosion of Cast-Iron Pipes, and *Tuberculation* as well, are not serious in much of England, nor in France, Belgium, and Holland. Most of the waters contain considerable lime, and do not cause tuberculation or corrosion. In the English Lake District, however, and in Wales and Scotland, where soft, upland waters are obtained, tuberculation is a serious matter. The use of spun cement linings in such cases is becoming common, although it is only about two years since their first employment. The first water pipe which I saw on my arrival in England was in Liverpool, — a 16-in. cast-iron pipe with cement lining. I understand that such linings are usually about $\frac{1}{2}$ in. in thickness, not so thin as our American foundries are applying.

The spun lining of asphalt and some inert substance like ground rock

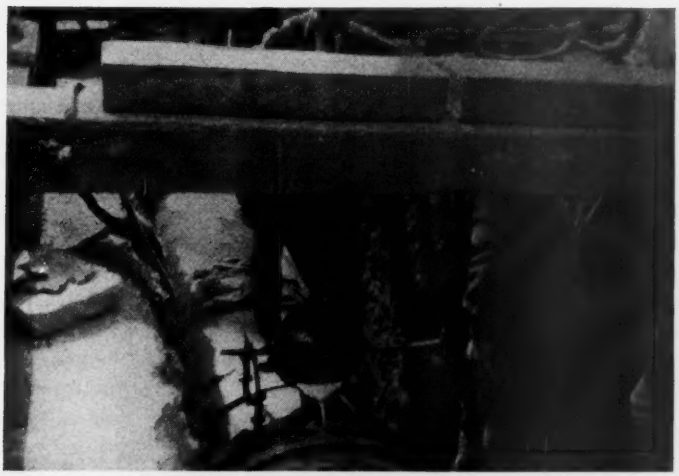

FIG. 3. LEAD POURING POT ON 36-IN. JOINT, LONDON, ENGLAND.

(Talbot lining, or similar thereto) is also receiving considerable favor, particularly for steel pipes. The new works of the Taf Fechan Water District in Wales, now under construction, are of steel pipes lined in this way. The same practice is being followed in a new system for Singapore, and I was told that the lining (which is approximately $\frac{1}{2}$ in. thick) showed no tendency to run at a temperature of 130.°

Main Pipe Joints are generally made in the same manner as in America, with lead and jute or hemp. In London, however, and to some extent throughout Britain, solid lead joints are commonly used.

In making solid lead joints, it is customary to insert a ring of soft lead and calk it lightly, to prevent the molten lead from running through into the pipes; after which the joints are poured and calked in the usual way.

Clay rolls are in common use, instead of the "pipe jointers" which are so common here.

A contractor laying 36-in. pipe in London was making use of a pouring pot mounted in trunnions on a saddle set on the pipe, instead of pouring from ladles. (Fig. 3.) In this way he was sure of completing the joint with one continuous pouring, and he was confident that he was getting much better joints in this way than by having two men with ladles, for instance.

Jointing Compounds, such as leadite, have been used little if any abroad. All the engineers with whom I talked were interested, as they were also in joints of cement, but were inclined to be skeptical as to their applicability. Some said that they were probably "too conservative" to try them. Others had had demonstrations which had not proved satisfactory. In one case, at least, if I understood correctly, the demonstrator knew but little about the material he was representing. He did not make it clear that the joint would grow tighter of itself after the water was turned on, and that some leakage when water was turned on did not necessarily mean that the joint was imperfect.

Two or three types of joint made with rubber packing rings, tightened by cast-iron followers and steel bolts, are in use, especially in France and the French colonies. The Gibault joint is, perhaps, the most interesting of these. This is made with plain end pipes and a special sleeve, against the ends of which two rubber gaskets are compressed by cast-iron followers drawn up by steel bolts. This joint can be deflected materially without leaking, and it therefore is of considerable interest where pipes are laid in unstable earth, particularly over coal workings where serious settlement is to be expected. The question arises, however, how long will the steel bolts last when buried in the ground, and what will happen to the joint if they rust out? In France, experience does not indicate that the corrosion is serious enough to cause concern; and even here, we are using bolted split sleeves for cutting in branches and, in some places, flanged or Universal pipe with steel bolts, and apparently with safety, as a rule.

Spacing between the ends of pipes appears to be the universal practice. Pipes are never allowed to butt together, but a space of $\frac{1}{4}$-in. or more is allowed between the spigot end and the bottom of the bell. This is for the purpose of guarding against serious strains which might result from expansion of the pipes. Under the most favorable circumstances, uniform bearing entirely around the circumference of a pipe is not to be expected, and the pressure concentrated at one point might produce stresses sufficient to account for split pipes. Whether pipes in the ground can expand sufficiently to produce such pressures has, so far as I know, never been shown; but it is easy to compute that the theoretical elongation resulting from a comparatively slight increase in temperature of the water is enough to exert an immense pressure, if the pipes are in contact.

The Depth of Pipes below the surface seems small, in comparison to New England practice. In France, depths of a little over a meter, say $3\frac{1}{2}$-ft., are common, and in London it is about 3 ft. or even less. Frost

rarely penetrates to any considerable depth in these localities. In Holland, too, the pipes are comparatively near the surface; but here the ground water stands so high that there is little danger of pipes freezing even in severe winters.

Gate Valves are inserted and located in accordance with the same general principles as with us. The small distribution pipes — 3 in., 4-in., 5-in., and 6-in. — are generally gated at both ends of the blocks. Larger feeder pipes may not be gated so frequently; indeed, lengths as great as a

FIG. 4. MARKERS FOR HYDRANT AND VALVES, OXFORD, ENGLAND.

mile between gates on 7-in. and larger pipes are not considered objectionable in London. Gates of the solid wedge type seem to be in universal use.

In pipes of large sizes it is common to employ valves of smaller size than the pipes, with reducers on either size.

Operating nuts are not mounted on gate stems; the stems are merely squared and tapered to take the wrench, which makes it possible to use smaller gate-boxes than we do. In London the box proper is about 15 in. high, with a rectangular hinged cover, having an opening about 5 in. square. A piece of 4-in. pipe extends from the box to the bonnet of the valve.

Records of valve locations are kept, much the same as is common with

us. In addition, in some cities, markers are placed on building walls or fences. Sometimes these show the distance to the valve and also the size of valve and of the main pipe from which the branch is taken (Fig. 4); sometimes, as at The Hague, the number of the valve and its location, by offsets in two directions. Enameled steel plates are commonly used for such markers.

Fire Hydrants. Almost without exception the flush type of hydrant is used, even in places as far north as Edinburgh and Amsterdam, where there is considerable snow in winter, and where the time lost in finding hydrants would be of considerable moment if fires were as frequent and as

FIG. 5. FIRE HYDRANT, THE HAGUE, HOLLAND.

destructive as is commonly the case in America. Practically, this does not seem to have proved a serious difficulty. Markers on buildings or fences seem to be universally employed.

The types of hydrant used at The Hague are shown in Figs. 5 and 6. As a rule, there is but one outlet for a $2\frac{1}{2}$, 3-in. or 4-in. hose. The valve of the English hydrant is similar to an ordinary gate valve, but is provided with a drip. Such hydrants are regularly installed on pipes as small as 4 in. Unless I misunderstood, fire engines of 400 gal. per min. are a common size, so the requirements for water are not nearly so serious as here. Some of the sidewalk drinking fountains are also provided with hose connections — not larger than $1\frac{1}{2}$ in.

In London the hydrants are paid for and maintained at the expense of the fire department.

Service Taps are almost invariably made in the top (highest part) of the main pipe. In London, when the pressure is light, it is common to

close the valves at both ends of a street and cut a hole in the pipe with a diamond point, then tap a thread and screw in a corporation. At The Hague I saw a tap made without shutting off the water, using a shield about 15 in. in diameter to protect the workman. This, however, was where the pressure was very light. (Figs. 7 and 8.) Tapping machines for tapping and inserting cocks under pressure are also in use.

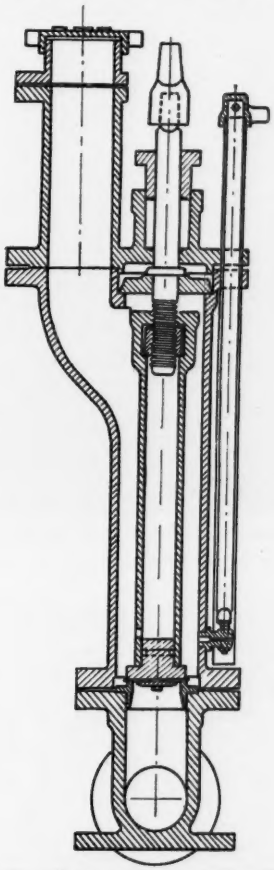

FIG. 6. FIRE HYDRANT USED AT THE HAGUE.

The practice of The Hague, which I understand is fairly common abroad, may perhaps be sufficiently novel, from an American point of view, to warrant a description. A cast-iron saddle, threaded for the corporation cock, is strapped around the main pipe by means of a U-bolt with a leather washer between it and the pipe in order to make a tight joint. The drill is then operated through the hole in the saddle until the hole is complete. When the drill is withdrawn the shield protects the workman except for

FIG. 7. DRILLING FOR SERVICE TAP IN 4-IN. MAIN PIPE, THE HAGUE, HOLLAND.

FIG. 8. SERVICE TAP IN 4-IN. MAIN PIPE, THE HAGUE, HOLLAND.

the moment during which he is removing the drill and replacing it by the cock, which is provided with a similar shield. After a few turns the cock is screwed in tightly enough to stop all further leakage.

The service or corporation cock generally used in England, and in many places on the continent of Europe, is an angle cock of the compression type. In some cases a plug cock is used, with lead gooseneck. Lead service pipes are almost universally used; indeed, I do not know of any other material used for service pipes abroad.

In The Hague, where possible, the main pipes in residence streets are laid beneath a sidewalk. Since in the towns all dwellings are built in blocks directly on the street line, the service pipes on this side of the street are very short. For the opposite side, a 1-in. pipe is laid across the street for each group of 6 houses, feeding into a 3-in. cast-iron header into which six corporation cocks are tapped.

One-half inch or $\frac{3}{4}$-in. pipes are generally used for house service.

In this country the common use of bolted saddles for service connections would be likely to be followed by excessive leakage after a few years, and an endless amount of trouble. The fact that they are generally used in the old water-works systems of Europe indicates that trouble from such construction is practically unknown there.

Meters. In England, meters on domestic services are not favored; indeed, they are absolutely prohibited in London, for fear that in the attempt to save money, too little water to maintain healthful conditions will be used. Hotels and establishments using considerable quantities of water are the only ones to which water is sold by meter. Rates are generally assessed as a percentage of the rentable value of the property.

In Holland, the water rates on residence property are similarly fixed, as a percentage of the annual rent, but meters are in common use as a check. A certain maximum quantity of water is allowed for each class of property and, if more than this is consumed, an additional charge per cubic meter is made for the excess; but no saving can be effected by using less than the stipulated amount.

The inferential type of meter is in universal use in Holland. It consists of a chamber containing a vane wheel upon which jets of water impinge. It has been found that these meters can be rated accurately, and they give good satisfaction; but, in good practice, they should be tested as often as once in two years. The particular meters which I saw are of German manufacture. Positive displacement meters of any type are unsatisfactory because of the lime deposit which quickly reduces the size of the measuring chamber.

In France, regulation of the quantity of water used has been made by means of stopcocks in which orifices of various pipes may be inserted. Whether this practice is still followed, I do not know.

Detection and Prevention of Leakage. British practice requires distribution systems to be so planned that any section may be supplied through

a single connection, which is provided with a by-pass for the insertion of a control meter, usually of the Deacon type. In London, the waste detection service is thoroughly organized and constantly in operation in some part of the system. The methods followed are exactly similar to those employed in our pitometer surveys, but apparently with much greater use of the stethoscope, and by constant practice their men became so expert, that they are able to detect incredibly small leaks.

The rapid and efficient operation of the leak detection service is much facilitated by the employment of special gate and service men, called "turnkeys," who are an important part of the organization in London. I do not know how far this system is in general use, but obviously it is not practicable in very small works.

Under this plan the city is divided into districts of limited size, in each of which a turnkey and an assistant are maintained. One of these men is always on duty, and all fire and police stations are informed where and how to reach him promptly. No one but the turnkey ever operates any valve or service cock. They are selected men and are carefully trained, and they work in coöperation with the water detection service and the fire department, and have authority to open or close valves as needed in case of accident, conflagration, or other emergency. The position is one of some dignity and responsibility. In London a turnkey's district ranges, roughly, from $\frac{1}{4}$ to 1 sq. mile, depending upon the density of population and the complexity of the pipe system.

Queen Mary Reservoir (London Water Supply). Although I devoted myself mainly to details of practice relating to distribution systems, I got such information relating to works of water supply as was available to me, and I made a visit to the new Queen Mary Reservoir of the London Water Supply, at Littleton. This is claimed to be the largest artificial reservoir in the world — that is, the largest reservoir entirely surrounded by embankments. It is not yet entirely completed, but will be in a short time. The water area is 722 acres, the capacity 8 100 million gal. (U. S.), and the perimeter is about 4 miles. The depth of water is 38 ft.

Most of you are aware that the water supply of London is obtained mainly from the rivers Thames and Lea; as there are no suitable sites for storage reservoirs on the Thames, and as a very large part of the total flow of the upper river is required, it is necessary to provide artificial basins at some distance from the river, and to pump the water to them at times when the flow is sufficient. The Queen Mary Reservoir is the latest and largest of these basins. The water flows through a canal from the river to a pumping station located near the reservoir bank, where it is pumped over the bank into the reservoir. The lift of the pumps varies from 30 to 46 ft. There are four 48-in. centrifugal pumps, directly connected to unaflow steam engines. Each of these has a capacity of 87 million gal. per day. From the reservoir the water flows to existing filters and is filtered and pumped into the distribution system.

Water Supplies in Holland. Some of the most important water supplies in Holland are derived from the ground near the sea — the so-called dune supplies. Among these are the supplies for Amsterdam, The Hague, and the North Holland Water Supply District, which includes more than 100 communities, comprising practically all of the peninsula north of Haarlem and lying between the North Sea and the Zuider Zee.

By careful study and much experimenting, the Dutch engineers have found out how to develop supplies of excellent water from the dunes, and how to determine just how much water can be obtained. It is readily seen that in a sandy soil, with salt water on both sides at no great distance, any

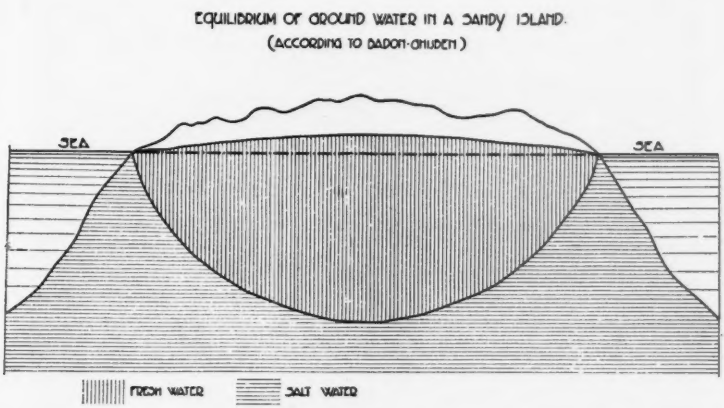

FIG. 9.

attempt to draw too much water will result in an inflow of salt water through the sand and a deterioration of the supply, which may never again be satisfactory if such deterioration occurs.

Figure 9 shows the theoretical form of the fresh-water accumulation in porous sandy earth between two bodies of salt water. Rain water percolates into the ground, and the slope of the water table results in some flow of fresh water through the sand to the sea. But if the hydrostatic balance at any point be considered, it is obvious that for salt water of a certain specific gravity, if ground water stands at a certain elevation above sea level, the line between fresh and salt water will be at some definite depth below sea level — in other words, if the difference in height between salt and fresh water columns is known, the corresponding depth to salt water, and the thickness of the fresh-water layer, can be readily computed.

While this does not exactly apply in practice, owing in part to the lack of a sharply defined line between salt and fresh water in the ground, and in part to lack of uniformity in the texture of the earth, it does provide a basis of estimating, from measurements of ground water elevation, the

amount of depletion of the fresh water storage in the earth; and by the help of careful observations and records it is possible to utilize all the available supply without endangering its quality.

Such waters are gathered by open channels, filter galleries, or driven wells, depending upon local conditions; are aerated and filtered, and pumped to elevated tanks or directly into the mains.

Figure 10 shows typical dune country from which such supplies are obtained.

The aerator nozzle used at one of the North Holland plants is the

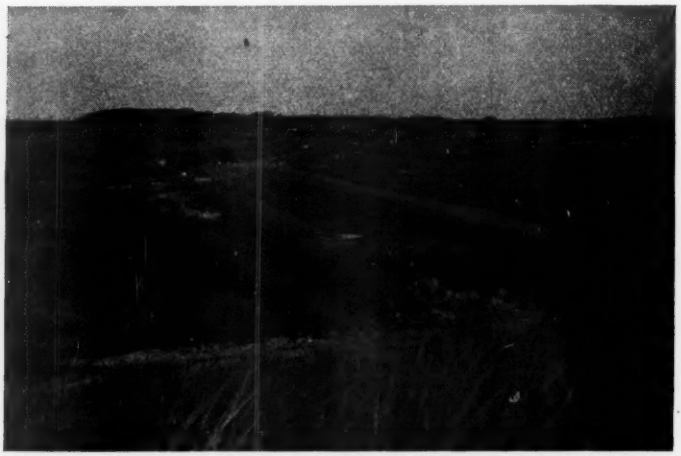

FIG. 10. COLLECTING WELLS AND CONDUIT, CASTRICUM, NORTH HOLLAND.

simplest I have ever seen and appears to be working satisfactorily. It is of the Sacramento type.

In these places they are actually consuming about 18 or 20 gal. per day per person, which is about all the water available. Amsterdam has developed all the water available to it from the dunes, and is now in need of additional water, for which it will probably be necessary to go a considerable distance to the east, — probably to the more elevated part of Holland, and it is possible that a surface water supply will be obtained.

DISCUSSION.

M. N. BAKER.* I merely want to note on the record, for the benefit of those who are interested further in water-works practice in England, the fact that there has recently been published a book entitled "Water Works Administration." This was published in England by an official of the Birmingham Water Company, and it goes into very considerable

*Associate Editor, *Engineering News Record.*

detail in regard to various things, some of which are touched upon by Mr. Sherman's paper.

MR. SHERMAN. Along that line, perhaps it might be well to speak a little further by calling attention to the publication of the British Institution of Water Engineers. That is a high-grade technical society, with strict requirements for membership. They publish an annual volume of proceedings, which is in the library of this Association at Boston, and any of the members who have spare time when they are in Boston will find it well worth their time to ask for those proceedings, which are well worthy of examination.

THEORY AND USE OF THERMIT HEAT UNITS IN RELIEVING ICE CONDITIONS.

BY HOWARD T. BARNES.*

[*Read September 15, 1926.*]

These kind words that Dr. Freeman has just uttered have touched me very deeply. Dr. Freeman came to me as the assistant many years ago and found me a struggling physicist in an out-of-the-way place, Montreal, and he encouraged me very much indeed,— in fact, if it had not been for Dr. Freeman I never would have written my book, probably. That has led on to further work, and this evening, in the time that is allotted to me, I wish to enumerate very briefly a little account of some of the new methods of ice control which I have been developing during the last two years as a result of this study which Dr. Freeman has so well outlined to you.

In September, 1910, I had the honor of presenting a paper† before this Association on Ice Formation in which I outlined the main results of a study of ice in the St. Lawrence River extending over many years. Since that time it has been my privilege to continue this study through the help received from the Department of Marine and Fisheries of Canada, the Hydro-Electric Power Commission of Ontario, the Cedar Rapids Power and Manufacturing Co., and others. Many new and interesting properties of ice have been found, chief among these being the method of ice control which I explained recently to you in a paper‡ published in *Water Works Engineering* of June 1st and 15th of this year, and which may have come to the attention of some of you. The application of these methods for the heat treatment of ice has been so fruitful of interesting results that I am desirous of bringing to your attention certain features of the many possible ways in which thermit can be used for ice remedial work, in the hope that you can be helped wherever ice proves a trouble in operating plants.

Water-Bearing Ice.

In ice-laden water the temperature can never differ much from 32° Fahr. and, indeed, no ice can form in water unless the temperature is below 32° Fahr. The first ice that is produced comes from the invisible ice molecules, which are always present in the water even at high temperatures. The ice flocculates as colloidal particles, and forms the true frazil ice observed in running streams. These ice molecules eventually pass through

*Professor of Physics, McGill University, Montreal.

† Journal of the New England Water Works Association, Vol. 24, p. 576 (1910).

‡ *Water Works Engineering*, Vol. 79, p. 649 (1926).

the stage of a crystal colloid and eventually assume the true crystal form of ice. The amount of frazil produced is proportional to the amount of super-cooling, which in turn is directly determined by the rate of heat loss from the water. The super-cooling in the water is, as I have repeatedly shown, only a minute fraction of a degree, 1/1000° or so, but this is essential for the passage of the water into ice. Methods for heating water for preventing ice have been proposed from time to time, and some very old patents exist. In general, the methods all use steam, hot water, air, or electrical energy for generating heat. Compressed air around racks and gates seems to be gaining in popularity in some places, but this is another way of supplying heat in small quantity by bringing up the under water, which is always warmer, and the heat of compression. The difficulty of all these methods is to get the heat to spread over a large enough area in large ice accumulations. Such heat is generated at too low a temperature to do more than warm the water in the immediate proximity of the heating agent.

Function of the Thermit Treatment.

It has always been a source of wonder to those working with ice to see how rapidly the sun relieves ice masses in the coldest weather. This is due to two causes: (1) the penetrating quality of the rays of the sun, and (2) the fact that only a small degree of super-cooling has to be relieved to loosen the binding force between the crystals. The penetrating quality of the sunlight is due to the energy coming from a very hot body in short infra-red rays and visible rays. Water and ice are practically black bodies to the long heat rays from a low-temperature source, but the short heat waves and light waves can travel a long distance before becoming completely absorbed. The absorption is the conversion of the radiant energy into heat energy in the water or ice, with consequent rise of temperature. Examples of this are well known to everyone, such as a block of ice honeycombed by sunlight.

If we could apply the sun's rays to the under side of an ice sheet, or inside an ice mass, we could readily prevent ice formation, but the sun can only act on the surface which is often very cold and scatters the heat as well as the light. Under the water the temperature is never low, and hence the action of the rays is rapid and effective. Unfortunately, we cannot apply sunlight under water except through exposed water surfaces, but we can try to imitate the sun and apply under water some highly incandescent body from which copious energy can be radiated in short wave-lengths. Two years ago I set to work on this problem after an intensive study of sunlight on the huge masses of ice in icebergs. I came rapidly to the conclusion that the solution of the matter depended on using intense heat. I use the word "intense," meaning heat at a high temperature, which would set up thermal strains and cause cracks in the solid ice. The heat wave which is generated was expected to penetrate the ice to relieve the binding force of the crystals. High explosives have proved disappointing in ice

for reasons now well understood, but there were no data on the cracking of ice by expansion.

On returning to Montreal from Newfoundland, in 1924, where my observations were made on the icebergs, I did some small-scale experiments with thermit, which I had used many years ago for illustrating high temperatures in my college classes.

What is Thermit?

Thermit is, no doubt, familiar to most of you. To those who are not familiar I may say that it is a mixture of metallic aluminum and iron oxide. When this mixture, which is absolutely non-explosive and cannot be burned with any ordinary fire, is heated, by an ignition powder placed on top of the mass, to a temperature of 2 800° Fahr., the aluminum burns at the expense of the iron, and liberates its heat of formation. The reaction is as follows:

$$3Fe_3O_4 + 8\,Al = 4Al_2O_3 + 9Fe$$

The reaction is so rapid that the mass quickly rises to around 5 000° Fahr. The molten iron carries the heat, which is at a temperature more than the hottest blast furnace, and my imagination pictured this mass half as hot as the sun suddenly exposed in a mass of ice. There was no previous experimental work to guide me and so I had to approach the trials with great caution. While the total heat of thermit is not nearly as large as from coal, yet the high temperature attained rendered the heat much more effective for my purpose than much more which I could have produced at a lower temperature. The thermit was, however, obtainable in any quantity at a fairly reasonable price, hence there seemed no limit to the possibilities of the material.

My early trial experiments have been sufficiently described in *Water Works Engineering*. Since that paper was prepared I have had other and interesting experiences with thermit, which have cast more light on the theory of the reaction in ice.

The important fact which is emphasized is the slow explosive wave which follows the passage of radiant energy through the ice. This is the *slowest* explosion known, and has proved to be ideal in lifting ice masses. All the force is upwards, as will be seen by referring to Fig. 1, which shows a block of ice weighing 400 lbs. blasted by a small charge of thermit ignited in a cavity cut in its upper surface. Everything is thrown upwards to a great height, with no downward force to speak of. The ice block is torn to pieces with the force of its structural explosion, and the hot molten iron and slag are scattered around. Besides the molten thermit, much gas is produced, which burns as water gas.

Here is a different kind of thermit, in a cardboard box. Some people object to cans because they think it affects the pump. In a can like that there is nothing to affect anything. But here is a cardboard; I can press

it into a cardboard. This tube will burn for a minute and a half and give an intensely hot flame of 5 000 degrees, which will burn under water. Once it starts you cannot put it out even with all your fire-extinguishing apparatus. Larger tubes to burn longer can be made, even 10 ft. long, and it will burn for 10 minutes or more, and can be put down into an ice pack to burn down and loosen the frazil. This is what I advocate for thawing

FIG. 1. — ICE BLASTED BY THERMIT.
Two lbs. of thermit reacting in a 400 lb. block of solid ice. Height of flames and burning ice 75 ft. Photo at night.

out hydrants when they get frozen. If you depend on electrical apparatus what do you have to do? You have to go for your electrical apparatus, which takes some little time to produce results. What do you do with this? Just draw off the cap and stick this thing down into the hydrant and the intense radiation will loosen it up.

I have never made a practical demonstration of this on a hydrant,

for this is really a new thing which I have just devised. I wish that this Association would form a committee to thoroughly test this out on some frozen hydrants with me. I would be glad to give my time to them in that way if they saw their way clear to doing that. That is something I would like to have you think about.

Thermit and Dynamite Compared.

I speak of comparing the action of thermit with dynamite, but in reality the two materials cannot be compared. In the first place, the force of dynamite is from its own expansion, which has little effect on the ice other than a shattering one. When detonated on solid ice, dynamite strikes downwards and crushes the ice into the ground. Thermit, on the other hand, causes this ice itself to blow upwards and tends to lift great ice packs. The energy of thermit goes into heat at such a high temperature that the ice is actually dissociated into its constitutent gases. To a limited extent, a steam explosion when water comes in contact with hot pipes resembles the thermit ice explosion. The thermit actually burns the ice, giving rise to bright flames. It is futile to compare an explosive with a non-explosive, but we can easily reflect on the results achieved in the problems of ice control.

Perhaps the most important point is that charges of dynamite cannot be used alongside of concrete structures, or inside a power house, or in the intake of pumps, while thermit can be. I have used very large charges of thermit against spillways and dams, and inside the penstock of turbines without harm. The slow heave from the thermit reaction in ice or water, cannot injure bridge piers or other similar structures, and usually no outward noise is heard. The ice being an explosive, who can compare dynamite with ice as such? Further, the safety of handling thermit, storing it, and transporting it are very much in its favor.

Recent Work with Thermit.

During the past summer I had the opportunity of using thermit heat units in the large masses of icebergs off the Newfoundland coast, with the anticipated result of cracking these masses. The action of the heat units in slush ice and frazil is somewhat different. I have tried to explain the function of this reaction which is so quick to relieve the sticky character of these masses. The dissociation of the ice and water generates volumes of gas and steam which shake the agglomerated masses and help the water to wash them away.

During my work last winter at the Cedar Rapids Power and Manufacturing Co. at Cedars, P. Que., on the St. Lawrence River, small heat units put in the frazil blocking the intake pumps of the water works of the town quickly relieved the congestion, and the pumps, which were frequently

FIG. 2. — RENO TRACTION BRIDGE, OIL CITY, PENN.
This bridge was put back onto its piers and saved without damage of any kind by thermit control of flood levels.

laboring with an impenetrable barrier of frazil, were started off again in a minute or two after the treatment. It is wonderful to see how rapidly the thermit loosens these frazil dams.

The work done last March on the Allegheny River in breaking the 25-mile ice gorge — where large charges of thermit heaved, shook, and burned the ice packs, allowing the water a chance to get down to float the ice and caused it to move out quietly without damage of any kind — is a wonderful tribute to the possibilities of the thermit treatment on a big

FIG. 3. — VENANGO, PENN.
View of ice gorged to level of railroad tracks before final removal by thermit.

scale. In a week after I arrived the entire gorge was made to move down very slowly, like a great glacier, disclosing to me the strong spots still holding. As soon as the weather moderated enough to allow the ice a chance to pass freely down the river without jamming lower down, the final attack was begun. There is no question that the weakening of the gorge from below prevented disastrous floods. Even as it was, the sun got ahead of me by two days on the upper pack and brought down several miles of ice into the pack still in place below Oil City at Reno, which nearly cost Oil City its traction bridge and power house. The flood was quickly relieved by burning out channels in this jam, and the bridge was put back safely on its piers without damage of any kind by lowering the ice slowly to a safe

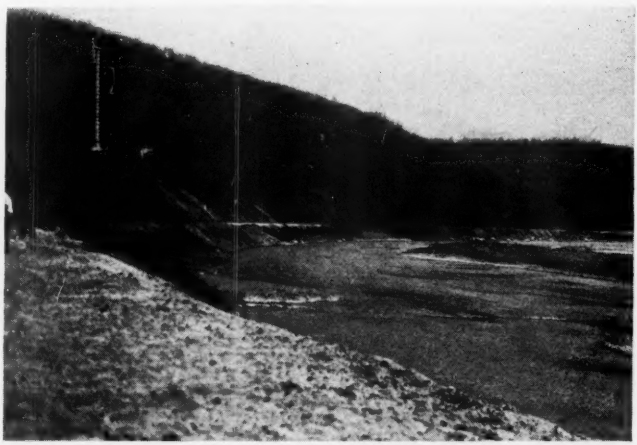

FIG. 4. — VENANGO, PENN.
Levels restored after removal of ice gorge by thermit.

distance. The bridge stood 18 in. above its piers on the ice all of one night until the thermit could be obtained by fast motor truck from Pittsburgh. This is merely mentioned to show the great possibilities of ice engineering work with the use of thermit. I wish I had time to write here of all the careful engineering work done in that fight, and the full importance of the results achieved.

These methods are so new and startling that many skeptics still exist, but I have every confidence in thermit in the fight against ice. Many other uses crowd in upon my mind, but take much time to develop and money to carry out. By winning the confidence of such men as are represented in this Association, I hope to be able to develop my methods in other and still larger applications.

To those of my former critics who calculated for me the relation between the heat in thermit and the weight of ice in the Allegheny River

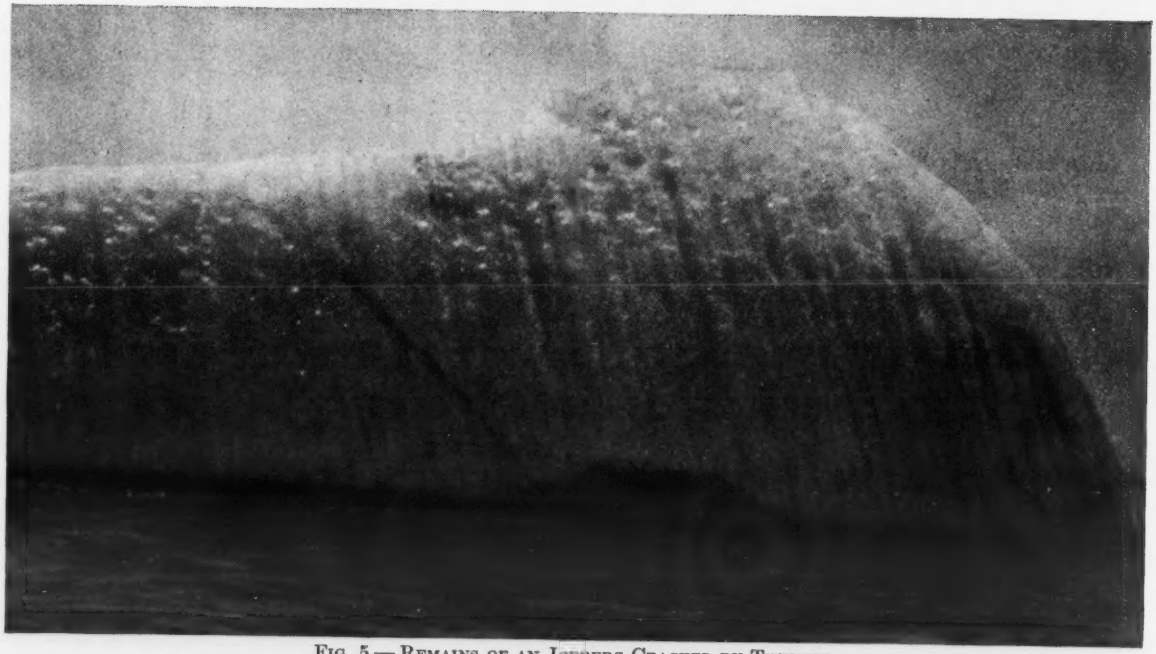

FIG. 5.— REMAINS OF AN ICEBERG CRACKED BY THERMIT.
Hole blown out by the charge seen on the water line. This piece alone was left and broke up rapidly.

I may say that it never was my intention to melt ice with thermit. After 20 years of research work in physics I can still realize such absurdity. I hope no one now will waste time calculating for me the number of thermal units which are required to melt an iceberg, because that has nothing to do with my problems.

In conclusion, let me again say how happy I shall be to help you in any of your ice problems and to have the thermit treatment become of real use to water-works engineers.

Discussion.

Charles W. Sherman.* There is just one question that I cannot help putting after what Dr. Barnes said about the small thermit cartridge being used for thawing hydrants. If the ice is going so soon and we will have such a high temperature, what is to be left of the hydrant? Isn't the hydrant going to suffer very seriously?

Dr. Barnes. That is what I want to experiment with. I want to have this Committee formed by the Association to work with me on some experimental hydrants and just freeze some and try them out in the worst cases you can possibly imagine, because those can be made in any size. You can get one that is too powerful or less powerful. It will no doubt do it if you have powerful enough ones. The thing to do is to select the right ones. If you are interested enough to try some experiments I should be delighted to coöperate with you in any way with my time in trying out these experiments. I think it ought to prove of value to the Association.

M. A. Sinclair.† I would like to ask Dr. Barnes how the thermit is ignited; if it is done with a common battery such as we use in igniting dynamite.

Dr. Barnes. It is ignited in several ways. The ignition powder is placed in the tube and you can use a time fuse, as I did on the ice packs, the ordinary dynamite time fuse, or you can use wires and shoot it off with a hot shot battery, or blasting fuse the same as a cap. It is quite easy to put off.

Allan F. McAlary.‡ I would like to ask if a small amount of it could be put in a frozen main. Would it break the main? Would it finally disintegrate the ice and let the water through?

Dr. Barnes. What I propose to do in the case of a pipe is to take a charge, set fire to it, and work it through into the water. It cannot hurt anything as long as the water is there. I have not actually tried the experiment but I would like to try it. I nearly did last year but I managed to get the pipe clear in another way. But I would like to take a chunk

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†Superintendent, Water Works, Bangor, Maine.
‡Superintendent, Camden and Rockland Water Company, Rockland, Maine.

of that and set fire to it and work it down in the pipe. I think it would clear it out very quickly.

WALTER P. SCHWABE.* I think this presentation of Dr. Barnes is perhaps the outstanding thing of this Convention and that we certainly ought to congratulate ourselves in having him come to us and make us acquainted with this discovery, if we may call it so. To my mind it certainly should prove of immense value to mankind. There is no telling where this will lead to in the way of preventing cocks and hydrants from freezing, and probably water mains.

I would move that we give Dr. Barnes a rising vote of thanks for coming here and presenting this subject to us.

(The motion was duly seconded and unanimously carried by a rising vote.)

DR. BARNES. I thank you most heartily for your kind expression. I want to assure you that anything I can do which will lead to relieving and helping in ice control will be very, very heartily done. It has been a long series of studies of my own, and I feel that if they come to fruition by which they will be enabled to benefit people and save the immense amount of money in this country that is lost through ice each year, my labors will not have been in vain. Taking the St. Lawrence River alone, where you close the Port of Montreal through ice for five months in the year, meaning a loss of $15,000,000 a week to the city of Montreal, if we can do something there I shall be very well satisfied, and I feel sure that it can be done. It is a question simply of the expenditure when it is needed.

But I want to assure this Association that I am deeply honored by their kind words and the expression which they have just given me.

*President, The Northern Connecticut Power Company, Thompsonville, Conn.

HEAD LOSSES IN THE RAPID SAND FILTERS AT CAMBRIDGE, MASS.

BY RICHARD G. TYLER,* W. A. DANIELSON,† AND MAURICE LEBOSQUET, JR.‡

[*Read September 14, 1926.*]

Tests have been made on filters by various investigators, notably Ellms, Fuertes, Pirnie, Daily, *et al.*, both to determine the characteristics of flow during the normal functioning of the filter and to investigate the behavior of the filter during washing. These tests have usually been made either on experimental units or on new filters containing comparatively clean sand which had not become coated by the accretions which accumulate with longer service. It is believed that the present tests will be of interest as indicating conditions as they exist in a plant under actual operating conditions.

For a complete description of the Cambridge Filter Plant, the reader is referred to a paper on "Rapid Sand Filtration at Cambridge, Mass.," delivered before this Association by George A. Johnson.[1] The water from Hobbs and Stony Brook reservoirs and from Fresh Pond is treated with aluminum sulphate as it enters the sedimentation basin. After a detention period of 2½ hours (nominal, but not usually obtained), it passes through a 48-in. effluent pipe to the influent flume in the pipe gallery and from that to the ten filter units, each 20 x 24 ft. in area and with a rated capacity of 1.4 m.g.d. Short detention periods are not effective for the soft, colored waters encountered in New England, as the floc forms with extreme slowness so that with short periods of settlement much of the floc is carried over onto the filters. At Cambridge this situation prevails, a fact which should be kept in mind in interpreting the data presented in this paper.

Each filter unit contains 27 in. of sand superimposed on 9½ in. of graded gravel drained by a Wheeler bottom. During this investigation the depth of sand was only 24 in. to 26 in. The wash troughs are 24 in. above the sand, while in normal operation the water stands at a depth of 40 in. on the sand. This depth is increased sometimes by 1 to 1½ ft. when additional water is being pumped from Fresh Pond. The water level varies also when the individual units are cut out for washing. When the sand was placed in the filters it had an effective size of 0.31 mm. and a uniformity coefficient of 1.85. The gravel is graded as follows:

5 lbs.	$\frac{7}{8}$ in.	to	1⅛ in. gravel for each Wheeler pyramid.
1¼ in. of	$\frac{5}{8}$ in.	to	$\frac{7}{8}$ in.
1¼ in. of	½ in.	to	$\frac{5}{8}$ in.
1½ in. of	$\frac{3}{8}$ in.	to	½ in.
1½ in. of	¼ in.	to	$\frac{3}{8}$ in.
1½ in. of	$\frac{3}{16}$ in.	to	¼ in.
2½ in. of	No. 12	to	$\frac{3}{16}$ in.

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†Major, Construction Division, Q.M.C., Washington, D. C.
‡Assistant Engineer, Morris Knowles, Inc., Pittsburgh, Pa.

Ipswich sand having an effective size of 0.31 mm., as previously stated, was used for the filters on which tests were made and, when placed, was washed thoroughly several times and then the upper 3-in., approximately, was removed. Some of the fine sand had also been carried out during the washing so that a total of 10 to 15 per cent. had been lost and the effective size was increased in the various units as shown in the following table. These values are for composite samples except that for 1926, which is the average for the upper 18-in. taken in 3-in. strata.

TABLE 1.

CHARACTERISTICS OF SAND IN CAMBRIDGE FILTERS.

Filter No.	Effective Size.				Uniformity coefficient.		
	Original.	Feb. 1923.	Nov. 1923.	Apr. 1926.	Original.	Feb. 1923.	Nov. 1923.
1	0.31	0.36	0.42	0.50	1.85	1.53	1.43
2	...	0.355	0.42	...	...	1.47	1.45
3	...	0.365	0.43	...	...	1.37	1.40
4	...	0.37	0.45	...	...	1.41	1.46
5	...	0.38	0.45	...	...	1.45	1.38
6	...	0.385	0.44	...	...	1.45	1.35
7	...	0.39	0.44	...	...	1.51	1.36
8	...	0.39	0.49	...	...	1.77	1.53
9	...	0.395	0.48	...	...	1.65	1.50
10	...	0.395	0.44	...	...	1.70	1.45

A continuous loss of fine material is apparent from this table, with a corresponding decrease in the uniformity coefficient. The latter effect is more marked for individual samples taken at any depth, which shows the efficiency of the washing process in grading the sand.

It is outside the scope of this paper to discuss the operation of the Cambridge Filter Plant, but some data on operation are required for an understanding of those factors which affect the head losses at various depths in the filters. One of these items that should be mentioned is the varying character of the water, with consequent variations in length of run. The filters operate for periods of from 5 to 18 hours, depending upon the character of the water, the nature of the floc, and the presence of certain algae. The high velocity method of wash is used with a rise of 28 in. per min., or a rate of 17½ gal. per sq. ft., or 8 400 gal. per min. per filter. The washing operation consists of drawing down the water till air is admitted into the voids of the sand, then starting the wash slowly and building up to the maximum rate in 1½ min. The filter is washed at this rate for 2½ min. after which the wash-water valve is closed. Another 1½ min. is required for this operation which is hastened by closing finally by hand. It is believed that this last operation is the most effective part of the wash, from the standpoint of grading the sand, for it permits the coarse sand to settle while the finer materials are still in suspension. Figure 1 shows the grading

of the upper 18-in. of the sand in Filters 1 and 5. Grading of the sand is necessary so that the fine material may be at the surface to support the floc and prevent its penetration into the bed.

Perhaps the most difficult and, at the same time, the most important

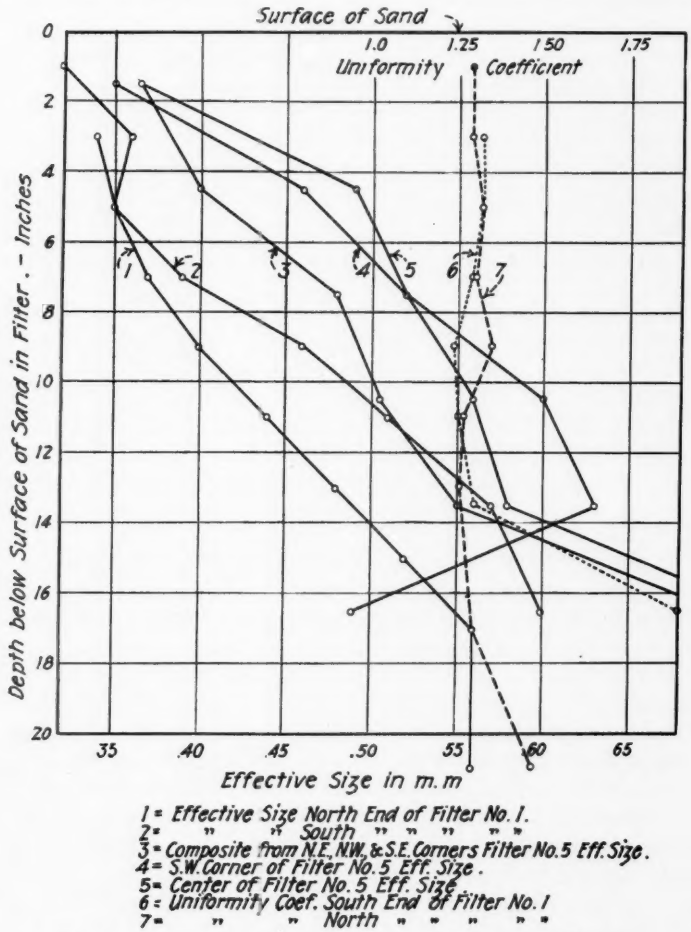

FIG. 1. — VARIATIONS IN EFFECTIVE SIZE WITH DEPTH IN FILTER.

part of any test is the design and construction of apparatus that will make it possible to secure the desired data. The problem in this case was to find the pressures at various desired depths in the sand or gravel without interfering with the normal operation of the filters. For obvious reasons it was undesirable to drill holes in the end of the filter adjacent to the pipe gallery for inserting the manometer tubes. After considering various possibilities,

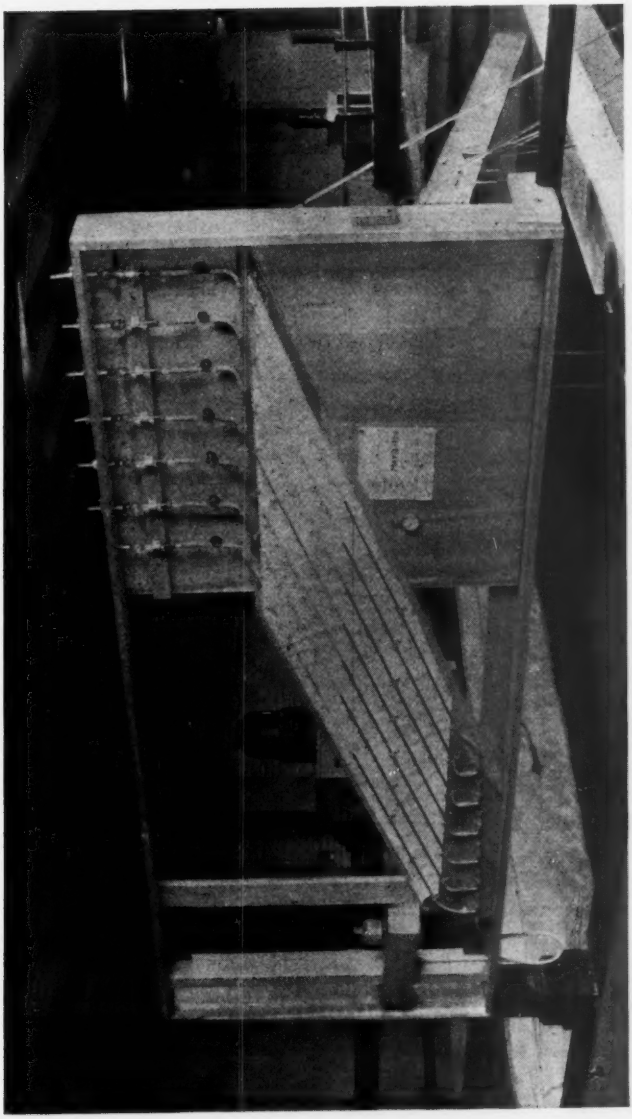

FIG. 2. — MULTIPLE-MANOMETER SET UP ON FILTER NO. 5, SHOWING CHARACTERISTIC READINGS.

the apparatus herein described was constructed and, after a few preliminary tests and adjustments, was found to work satisfactorily. It was desired to have the manometer gages above the operating floor where there was better light and they could be read more conveniently and accurately. Figure 2 shows a photograph of this apparatus.

In order to accurately register the pressure at definite points in the filter, slotted $\frac{1}{4}$ in. pipes were placed with the slot horizontal and at the desired depth and connected through glass tubing to the mercury columns of the multiple-manometer. The slots were small enough to prevent the easy entrance of sand. These pipes were later replaced by small copper gage tubes with the end flattened into a slit. The tubes and piping were filled with water, a connection being left at the top for connecting a vacuum pump for this purpose. Air from leakage or released from the water in the tubes was collected in a bulb at the highest point of each manometer and was withdrawn as occasion demanded. These accumulations of air had no effect on the accuracy of the readings and were so inappreciable as to cause no trouble. Mercury manometers were used as they gave sufficient accuracy in the inclined position shown and also permitted compactness of apparatus. All manometers had one leg in common. This consisted of a bottle or reservoir of mercury whose elevation could be accurately adjusted by a clamp which served as a vernier adjustment. One manometer measured the head acting at the surface of the sand and by adjusting the mercury column so this should read zero, each of the remaining manometers read directly the loss of head in the sand above the gage tube to which it was connected. By shifting the adjustment with the changes in water level in the filter, it was not necessary to correct manometer readings for these. The slope and spacing of the manometers were computed so as to use a sheet of Plate A profile paper as the scale by which the manometers were read. By drawing a line through the zeros of all manometers, the tops of the columns of mercury gave, at any moment of the test, a characteristic curve representing head losses at the various points. It was easy to see if anything unusual was happening to any manometer by noting its variation from this usual form of curve.

A test consisted in setting the gage tubes at the predetermined depths in the filter to be investigated, holding the tubes rigidly in place by clamping them to the side of a wash trough. Zero readings were taken before the filter was started, as a check on these depths. Readings were then taken at one-hour intervals until the filter was shut down preparatory to washing. A similar procedure was followed to determine pressures during the washing process, but readings had to be taken so rapidly during this operation that it was found easier to photograph the manometer board together with a watch with a second hand, so that more accurate time and pressure readings could be read from the photographs. Figure 2 shows the type of record thus secured. The chart was dated as shown to prevent error in tabulating the data later.

Figure 3 gives typical results for one of the runs made and is typical for the three filters tested. These curves are similar to those used by Pirnie in his work on the experimental filter at Harvard University,[2] and by

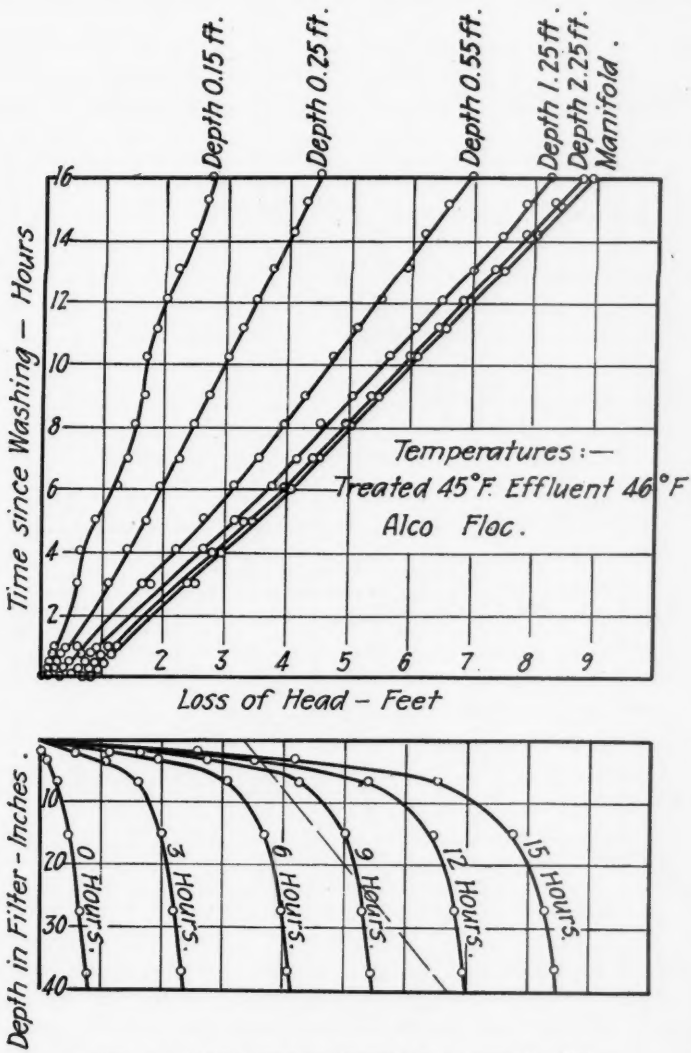

FIG. 3. — HEAD LOSSES IN FILTER NO. 5, APRIL 21, 1926.

Miller with reference to the work of Fuertes at Steelton, Penn.[3] The relative pressures at any point in the filter for a given time can be taken from these. Points falling to the right of the inclined, dashed line have less

than atmospheric pressure; those to the left have pressures greater than atmospheric. The greatest head loss is in the upper half-foot of the sand. This is more easily seen from Figs. 5 and 6 which give the variations of the hydraulic gradient, $\frac{h}{l}$, with depth and time. In Fig. 6, for example, this head loss per unit depth of sand is about constant for the upper 0.25 ft. depth. Between 0.25 ft. and 0.55 ft. depth it has decreased to about 50 per cent. of the surface value and continues to decrease rapidly with depth

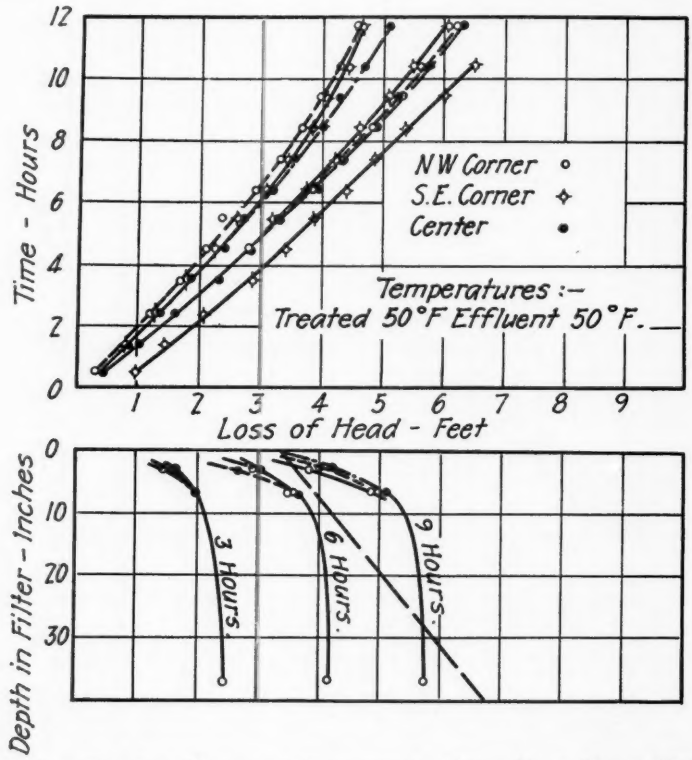

FIG. 4. — HEAD LOSS HORIZONTAL DISTRIBUTION. FILTER NO. 5, MAY 1, 1926.

to about three per cent. of that value at the top of the gravel. In Fig. 5 the sand at 0.25 ft. depth behaves in a very erratic manner, which may indicate a shifting in the position of the sand particles due to compaction as the head is built up, or the breaking through of the surface sand, as mentioned later. This behavior was noticed in other runs also. The head losses in the individual filters fluctuate from day to day. Figure 4 shows the uniformity of head loss in different areas of the filter and indicates that the washing of the filter is quite uniform over the bed.

While these tests were in progress, Mr. Harold C. Chandler, chemist at the plant, was experimenting with "alco floc," or sodium aluminate, as a coagulant. In this connection, Figs. 5 and 6 are of interest in showing the difference between the alum and alco floc. Alum was used in Fig. 5 while alco floc was used in Fig. 6. If the curves are superimposed upon each other, it will be seen that for depths below the upper 0.25 ft., the filters functioned in an almost identical manner. But the head loss at the surface is much greater with alum than with alco floc, showing a greater removal by straining with the former than with the latter. The tests were made at the season of the year when the greatest trouble is experienced with poor

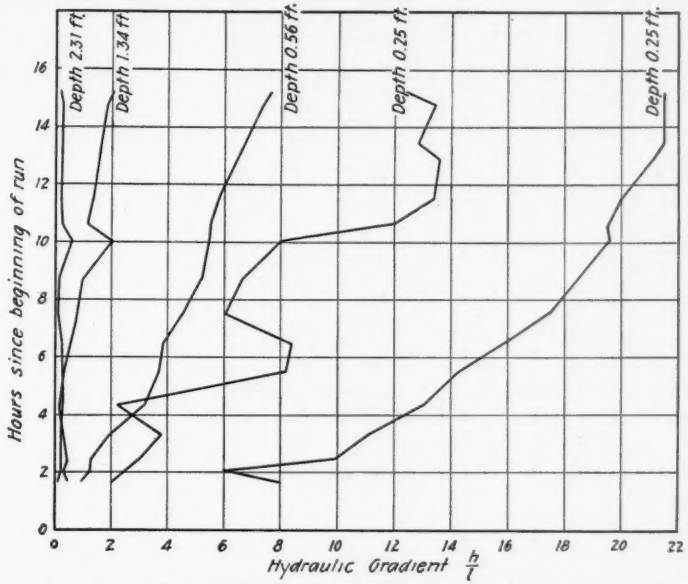

FIG. 5. VARIATIONS IN THE HYDRAULIC GRADIENT WITH TIME. FILTER NO. 1. MARCH 26, 1926. ALUM FLOC.

flocculation and passage of color through the filters. Mr. Chandler reports slightly more color in the effluent with alco floc than with alum, as shown in Table 2.

It is interesting to note the high head loss that can be built up in the surface layer of the sand as shown in these graphs. In Fig. 5, at the end of the run, the unit head loss in the upper 0.20 ft. was 21.5 ft. That even higher gradients exist in the immediate surface is seen from Fig. 7, where a value of 63.2 ft. per foot was reached in the upper 0.10 ft. The upper 0.05 ft. broke through and at the end of the run a crack was found to extend downward to this gage tube. This break occurred after 2½ hours and at a comparatively low head loss, which may have been due to the lowered frictional resistance of the surface sand with its larger floc content. This

TABLE 2.

Characteristics of Water during Time of Investigation.

Date, 1926.	Length of run. (Hrs.)	Color.			Alkalinity.			CO_2.			Turbidity.			
		Raw.	Tr.	Eff.	Raw.	Tr.	Eff.	Raw.	Tr.	Eff.	Raw.	Tr.	Eff.	Temp.
March 19	16.6	37	40	6	16.0	5.0	19.0	5.5	17.0	5.0	..	..	..	..
March 26	16.3	38	38	5	15.0	4.5	19.5	5.0	17.0	4.5	..	..	..	..
March 29	15.6	35	31	2	15.0	4.5	19.0	4.5	16.0	4.0	..	..	..	..
Average for March	17.6	37	38	6	15.0	5.0	19.5	5.5	17.0	4.5	2	5	0	38
April 8	15.8	30	26	0	14.0	4.0	17.0	4.5	15.5	4.5	..	..	..	..
April 21	16.5	39	39	11	10.5	9.5	10.5	4.5	4.5	2.0	..	..	..	..
April 22	16.3	40	40	9	10.5	9.0	12.0	4.5	4.5	2.0	..	..	..	..
April 23	15.2	38	36	8	11.0	8.5	11.0	2.5	5.0	2.0	..	..	..	..
Average for April	15.0	35	33	3	12.5	6.5	14.0	4.0	10.0	3.3	2	4	0	44

Note. April 17–29, treatment consisted of 0.4 g. p. g. alco-floc; 0.6 g. p. g. alum; 0.2 g. p. g. soda ash.
Prior to April 17, treatment consisted of about 1.4 g. p. g. alum; 0.8 g. p. g. soda ash.
Chlorine at 1.65 lb. per million gal. average.

test was run to find the distribution of head loss in the immediate vicinity of the surface. The filter is here seen to be supporting most of the floc on the surface, and as the clogging proceeded, fine, shallow cracks occurred over the surface, permitting the water to work down into them, building a mat on the side walls of the break, and thus increasing the effective filter area. This phenomenon has been described by other investigators.

The action of the alco floc in penetrating the filter is typical of the condition which exists during the spring when poor flocculation is most

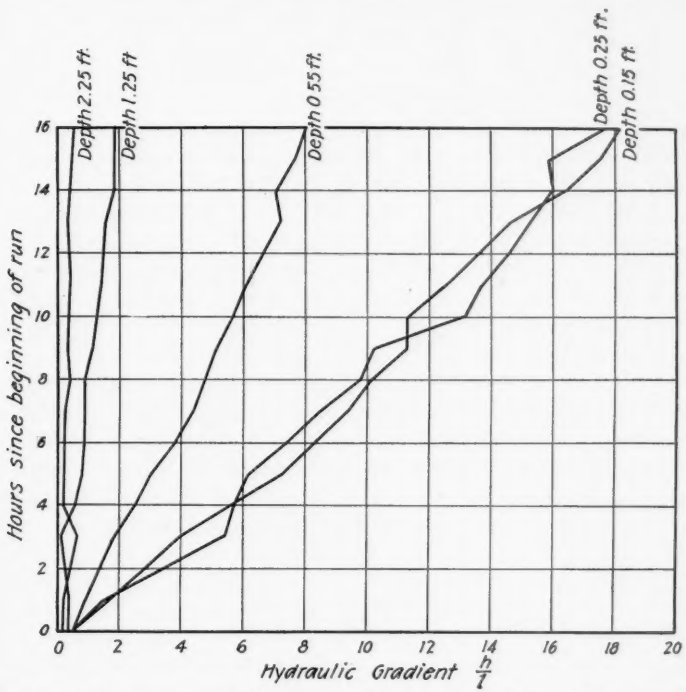

FIG. 6. — VARIATIONS IN THE HYDRAULIC GRADIENT WITH TIME. FILTER NO. 5. APRIL 21, 1926. ALSO FLOC.

frequent. Mr. Chandler states that during the normal operation of the filters they are cut out for washing at a head loss of 8 or 9 ft., but with this finer floc, at head losses of 5 or 6 ft., an increased amount of color, bacteria, and coagulant appears in the effluent and it becomes necessary to wash.[4] There is less surface clogging under these conditions, and the whole filter acts more as a settling basin. The runs are longer, reaching a maximum of 18 hours, while with the coarser floc formed during the summer, which is removed by surface straining, the runs may be as short as 8 hours, with an extreme minimum of 4 hours. During the winter months the run averages 12 or 13 hours. Certain algae also have a marked effect upon

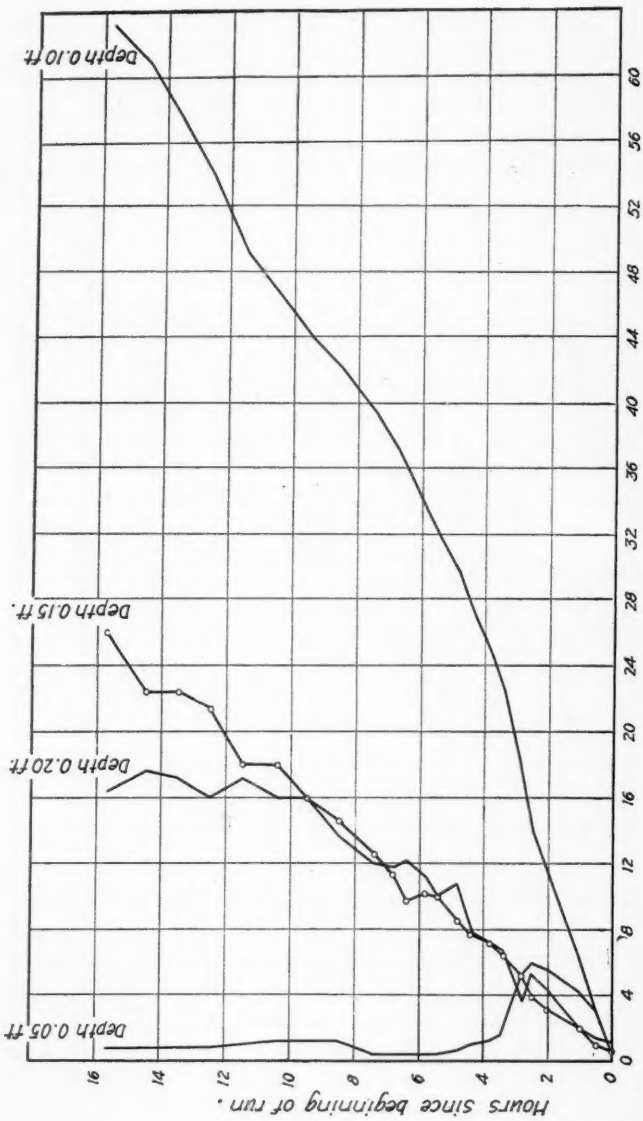

FIG. 7. — VARIATIONS IN THE HYDRAULIC GRADIENT WITH TIME. FILTER NO. 5. APRIL 19, 1926.

length of run. Thus its length is fixed by head loss in summer and by quality of effluent in winter.

With fine floc, a sand of smaller effective size is required for retention of the floc on the surface of the filter. This would also result in shortening the run. With coarse floc, greater difficulty is encountered where the detention period in the sedimentation basin is short, but with longer periods, a sufficiently large proportion of the floc will be removed before reaching the filter and the run may be reasonably long. As has been found at other plants, there are times, as in the summer, when coarse sand is more desirable while at other seasons, notably early spring, fine sand would be more effective. Since these tests were run, four of the filters have been re-sanded, three inches of fine Ipswich sand being added, which, after washing, brought the effective size of the surface materials to 0.28 mm.

Figure 8 shows the head losses during washing. The discharge built up gradually, reaching a maximum in 80 to 90 secs. and remaining constant during the $2\frac{1}{2}$ to 3 min. wash, then dropped gradually during the $1\frac{1}{2}$ min. closing of the wash-water valve. The control valve is only about $\frac{2}{3}$ open at this maximum rate and continues to open slightly as the head falls in the wash-water tank, thus keeping the rate constant. The sand is lifted and held with the grains separated by films of wash water. The pressures registered on the manometers appear to be about equal to the static head, due to a liquid of specific gravity equivalent to the mixed sand and water, dropping gradually as the water clears.

In order to investigate the relationship existing between the permeability of sand as determined by laboratory tests and that existing in the filter, this function of the sand from various depths in the filters was found by using the permeameter shown in Fig. 9. Determinations were made both on the dirty sand as it came from the filter and on the same sample after the dirt and floc had been removed by hand-washing. The material thus removed formed a heavy floc on standing. Difficulty was encountered in collecting the samples from the different depths in the filters, especially since it was desired to determine the percentage of voids in the samples as taken. The method finally used was to push or drive a channel of galvanized iron into the sand to the desired depth. The channel was shaped to form three sides of a box, while the edges of the metal served as guides to hold the lid which was next pushed down over them. These guides flared slightly at the lower end so as to draw the box together and slightly compress the sand and prevent its falling out when the sample was withdrawn. This method was not entirely successful.

The permeameter was designed and constructed by one of the writers (W. A. D.) under the supervision and with the advice of Dr. Charles Terzaghi whose experience in the testing of soils made his assistance of great value in this phase of the investigations. The cylindrical container was made of glass, for observation purposes, while the metal parts were of brass. The test procedure consisted in placing the desired depth of sand (3 to 6

cms., depending on amount of material available) on a wire mesh platform in the cylinder after having brought the water level to a few cms. above this platform, taking care to remove by suction all of the air bubbles clinging

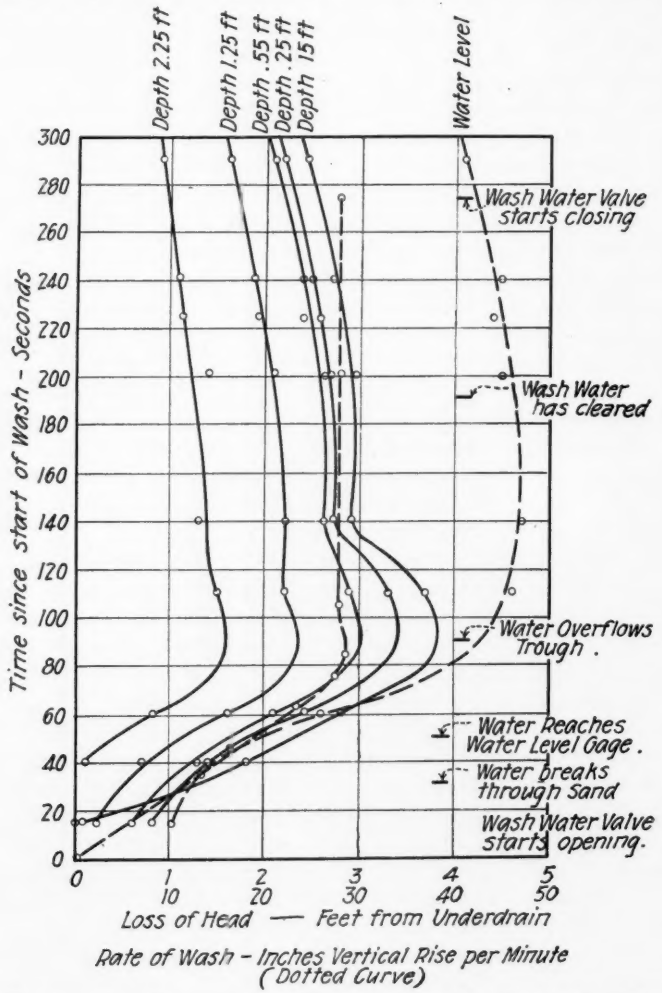

FIG. 8. — HEAD LOSSES DURING WASHING. FILTER NO. 5. MAY 1, 1926.

thereto. The sand sample had been previously prepared by filling the voids with water in which it stood for some hours. It was placed with a spoon on the submerged platform, tamped and leveled, care being taken to perform all of these operations under water. During the entire test the water level should never drop below the surface of the sand and permit air

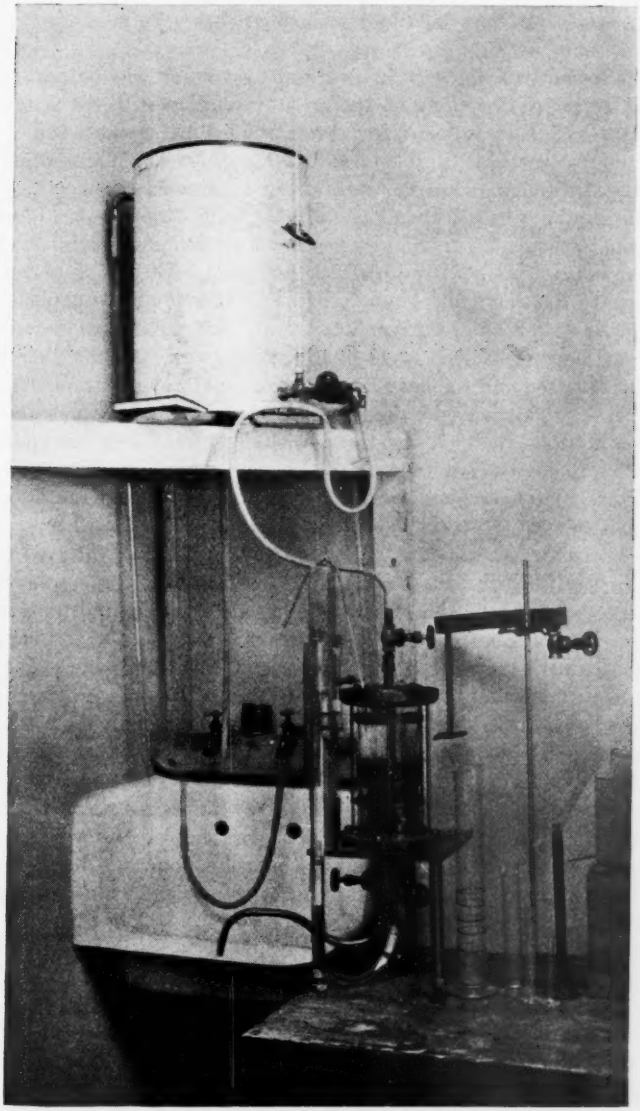

FIG. 9. — PERMEAMETER WITH SUPPLY TANK.

to get into the voids. After the test was completed, the sample was sometimes stirred to see if air remained in the voids, and it was found that the above method was fairly efficacious, though not perfect, in eliminating the air.

The weight of sand was known and its volume was determined by reading the depth of column on the loss of head gage with the water level coincident with the sand surface. From the volume, weight, and specific gravity, the percentage of voids could be determined. Water which had been passed through an air-removing device to prevent its collecting in the sand during the test, was then passed through the sand, the head loss was read from the gage, the discharge measured for a definite time interval, and the temperature read. Readings were taken at head loss increments of 1 cm. up to the maximum possible with the sample and apparatus, runs being made with both upward and downward flow. The test started with downward flow up to head losses of 16 to 18 cms. Then the direction of flow was reversed and the head built up to about 75 per cent. of the depth of the sand. This was the maximum safe limit beyond which the sand grains would be lifted. A check run with downward flow completed the test.

Figure 10 gives typical results thus obtained and these are also tabulated in Table 3. The coefficient of permeability, k, is in cu. cms. per sq. cm. of horizontal section per sec. at unit hydraulic gradient, and can be read directly from the chart for a head loss equal to the depth of sand column tested. This value can be converted to the desired temperature and per cent. of voids by applying Terzaghi's formula for permeability.[5] For comparative purposes, the column k red. has been added with k for 50 per cent. voids and temperature of 10° C.

In order to determine the efficacy of the method of air removal, a test was run on a sample in the usual way and again after the air had been removed by boiling, which is the most effective method of obtaining this result. The results shown in Fig. 10 indicate that the error from this source was only about three per cent. It is believed, however, that the soaking method used is more nearly similar to conditions found in the filter which has air accumulate during periods of negative pressure which may be only partially removed during washing.

From this curve it is seen that the head loss in the dirty sand may be as much greater than that in the clean as 59.3 per cent. in the case computed below. To compare the permeability as determined in the laboratory with that found to obtain in the filters, the following figures are presented. On April 21, a total head loss of 0.54 ft. in the upper 15 in. of Filter No. 5 was observed for a rate of 1.4 m.g.d. Tests on the sand for this depth in this filter, and with the same rate of flow, a temperature of 7° C. and per cent. of voids of 43.7 as obtained in the filter, would give a head loss of 1.28 ft. for the clean sand and 2.04 ft. for the dirty sand. The latter would represent the average condition just after the filter had been washed.

The discrepancy between these figures is greater than one might expect and suggests that laboratory tests, as run in this investigation, would give little assistance in predicting the behavior of the sand in the filter. It does not follow, however, that the results obtained in either case are in error,

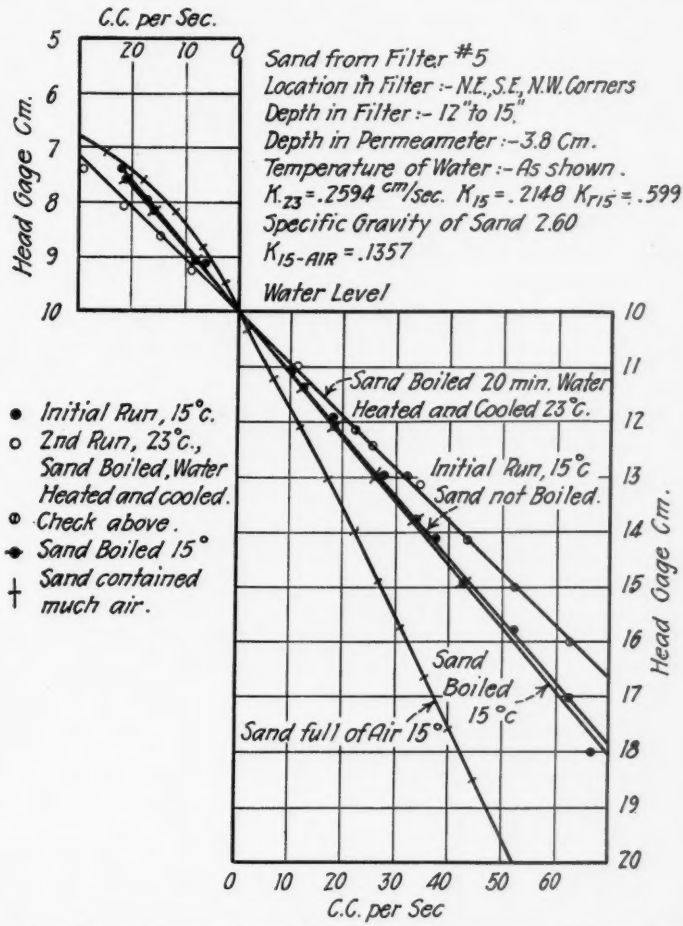

FIG. 10. — PERMEABILITY OF SAND IN FILTER NO. 5. 12 INCHES — 15 INCHES DEPTH. SHOWS EFFECT OF BOILING ON AIR REMOVAL.

but does show the difference existing between the sand in the filter and under the conditions of the tests. In the filter, the sand particles are surrounded by a film of coagulant and foreign matter from the water, and as pressure is applied to the filter surface, these particles pack together and force some of the surrounding film into the voids, clogging the filter more

TABLE 3.

CHARACTERISTICS OF SAND SAMPLES. FROM FILTER NO. 1.

No.	Depth in filter. (in.)	Condition.	Temp. Cent.	k cm^3/sec.	k red.*	Voids in perm.	Sp. Gr.	Effec. size.	Unif. coef.	Surf. mod.	Spec. surf.
1	0–3	Clean	17.5	.0696	.138	38.3	2.58	0.365	1.20	29.01	71.7
1-a	...	Dirty	16.0	.0684	.0697	48.0	...	...	...	...	...
2	3–6	Clean	16.0	.0905	.167	39.7	...	0.40	1.22	26.23	63.6
2-a	...	Dirty	15.0	.0774	.110	43.2	...	...	...	...	...
3	6–9	Clean	14.0	.1185	.238	39.2	...	0.48	1.19	21.52	52.5
3-a	...	Dirty	18.0	.1268	.230	39.2	...	...	...	...	...
4	9–12	Clean	15.0	.2103	.548	38.4	...	0.505	1.15	20.89	51.7
5	12–15	Clean	15.0	.2148	.599	37.6	...	0.55	1.56	16.60	41.5
5-a	...	Boiled	23.0	.2594	.502	37.6	...	...	...	...	...
5-b	...	Air filled	15.0	.1357	...	...	...	...	...	...	...
6	15–18	Clean	14.5	.2890	.588	38.8	2.61	0.71	1.24	14.60	35.8
6-a	...	Dirty	15.0	.2110	.400	39.9	...	...	...	...	...

* red. $= \frac{k}{\text{for } 10^\circ \text{ C.} + 50 \text{ per cent. voids.}}$

TABLE 4.

Sieve Analysis of Sand in Filters.

No.	Depth in filter. (in.)	Per cent. passing sieve number.									Remarks.
		100	65	48	35	28	20	14	10	8	
1	0–3	0.27	0.55	1.6	36.5	98.4	100.0	...	...	...	Filter No. 5. Composite from N.E., N.W., and S.E. Corners.
2	3–6	...	...	0.6	17.9	91.2	99.6	100.0	...	...	
3	6–9	...	...	...	3.0	54.5	92.0	99.0	100.0	...	
4	9–12	...	...	...	0.64	65.6	73.3	95.6	100.0	...	
5	12–15	...	...	...	0.10	21.1	64.3	91.4	99.0	100.0	
6	15–18	...	...	...	...	13.0	52.1	85.0	97.0	100.0	
7	0–3	0.90	1.6	2.6	33.0	96.2	99.0	100.0	...	...	Filter No. 5. From S.W. Corner.
8	3–6	...	0.13	0.13	3.9	69.1	98.0	99.6	100.0	...	
9	6–9	...	...	0.00	3.6	17.2	63.3	91.0	98.5	100.0	
10	9–12	...	...	0.00	0.12	9.3	49.4	84.0	97.0	100.0	
11	12–15	...	...	...	0.00	7.1	42.7	80.7	100.0	...	
12	15–18	...	...	0.25	4.97	24.0	52.4	81.8	100.0	...	
13	0–2	1.2	2.2	4.6	51.2	94.8	97.2	100.0	...	...	Filter No. 1. Unwashed.
14	2–4	0.45	0.77	1.9	38.7	98.9	99.5	100.0	...	...	
15	4–6	0.82	1.2	2.7	39.2	98.5	99.8	100.0	...	...	
16	6–8	0.31	0.82	1.7	31.6	99.0	99.8	100.0	...	...	
17	8–10	0.16	0.32	0.75	13.0	99.0	99.9	100.0	...	...	
18	10–12	...	0.11	0.22	6.9	86.8	99.8	100.0	...	...	
19	12–14	...	0.12	0.17	3.0	59.0	99.7	99.0	100.0	...	
20	14–16	...	...	0.12	1.3	34.1	89.0	99.1	99.9	100.0	
21	16–18	...	...	0.10	0.57	19.8	71.5	95.0	99.2	100.0	
22	Below 18	...	...	...	0.58	17.2	63.7	87.6	93.2	100.0	

than would occur with clean sand. In the permeameter tests, the sand was more compact and the results corrected to the proper voids ratio by using Terzaghi's formula which is for clean sand and would not be applicable without modification for a dirty sand, for the above-mentioned reason. The results are therefore not directly comparable, as comparative tests should be made with the same voids ratio in the sample as in the filter. Data from tests similar to these should therefore be used with caution.

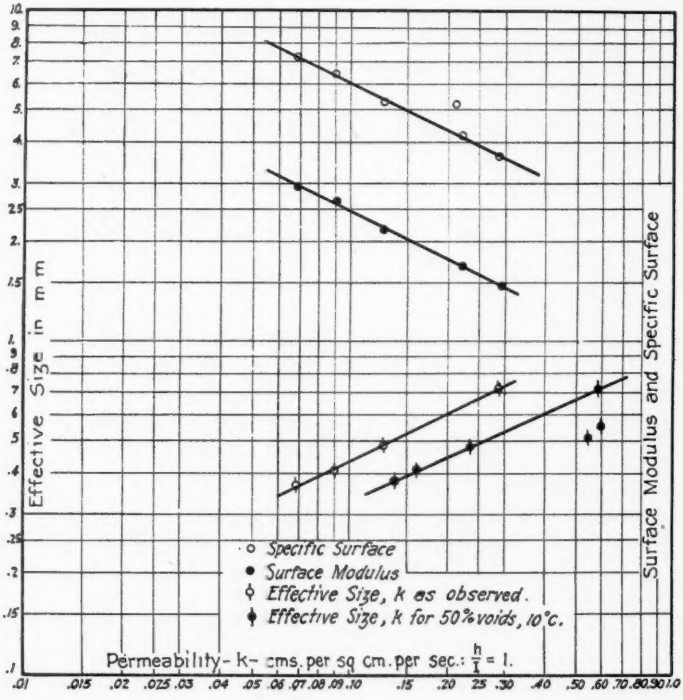
Effective Size in m m
Surface Modulus and Specific Surface
Specific Surface
Surface Modulus
Effective Size, k as observed.
Effective Size, k for 50% voids, 10°C.
Permeability - k - cms. per sq cm. per sec.: h/l = 1.

FIG. 11. — RELATIONSHIP BETWEEN PERMEABILITY AND EFFECTIVE SIZE, SURFACE MODULUS AND SPECIFIC SURFACE.

Figure 11 shows the relationship between permeability and the factors' effective size, surface modulus, and specific surface. It will be seen that for sands that are so nearly alike and with diameter of grain as its only important variable, the results obtained by these different methods are of about equal accuracy.

SUMMARY.

From a study of the above data and from observation of the operation of the plant during the tests, augmented by information furnished by Prof. M. C. Whipple and Mr. H. C. Chandler, the writers have arrived at certain conclusions which may be summarized as follows:

1. Head losses due to the friction in the sand itself are relatively unimportant when compared with those due to clogging or to the floc film on the filter surface. The size of the sand is more important from the standpoint of its effect on the length of run.

2. With proper washing technique, a fairly complete separation and segregation of the sand grains of different sizes can be obtained.

3. With the coarse sands used in filters (0.35–0.45 mm.) this segregation is necessary for the most effective removal of suspended solids by the filter.

4. The effective filtering stratum consists of the floc layer on top of the sand and the fine surface sand which supports it.

5. The coarser sand at depths below 0.5 ft. has only slight value in removing solids that have passed through the finer surface layer. Its principal function is to support the effective filtering stratum and to furnish the intermediate sizes between the sand of that stratum and the gravel below.

6. The small uniformity coefficient usually specified is not so important where the floc carried over onto the filter is of fair size and toughness so that it is retained on the surface. For a given effective size, a larger uniformity coefficient would give a more uniform grading off into the gravel than is at present secured.

7. It would appear to be more logical to specify filter sands by stating the effective size to be obtained in the top layer (say 3 in. depth), after specified washing, and secure thorough grading throughout the vertical section by proper washing technique, as has been done at some plants.

8. A larger effective size is permissible where floc is consistently coarse or where the detention period in the sedimentation basin is relatively short. Where the condition of the water or the plant is such as to peptize the floc, color, etc., a smaller effective size is needed. Thus at St. Louis an effective size of 0.38 mm. was the smallest desirable, while at Cambridge 0.28–0.30 would be nearer the limiting size, at periods of poor flocculation.

9. The runs vary with coarseness of floc, and the coarsest, most rapidly formed floc is not necessarily the best, as length of run may be too short. For best operating conditions, some intermediate condition is required, depending on settling capacity.

10. With coarse floc, removal is by surface-retention, while with fine, the filter functions more as a sedimentation basin with greater removal in the voids.

11. It seems possible that depth of sand might be decreased where a larger uniformity coefficient gives more rapid grading from top sand into gravel sizes.

12. The filter surface breaks through the upper 0.05 ft. or more in numerous fine cracks which increase the effective surface area of the filter. In no case did these cracks reach the gage tube at 0.10 ft. depth.

13. Negative pressure occurs first at about 0.50 ft. depth and extends

downward, but eventually upward also as clogging of the surface proceeds, finally extending from the bottom upward to within about 0.20 ft. of the surface as shown in Fig. 12. These depths vary with the characteristics of the floc.

14. A greater proportion of positive to negative head in the filter might possibly be advantageous in giving longer runs and might minimize trouble from the filter becoming air-bound. There was, however, no evidence of trouble from this source in the filters tested, and there seemed to be very

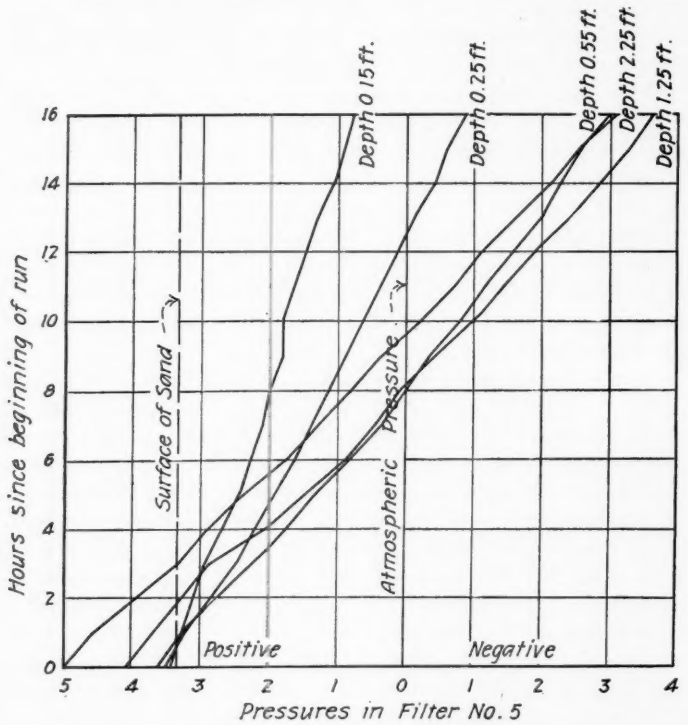

FIG. 12. — TESTS ON APRIL 21, 1926.

little air released in the filters. Sudden increases in the positive head as occurred at times when the water depth on the filters increased, appeared to compact the surface of the filter and cause a sudden increase in head loss.

15. With aluminum sulphate floc, a greater per cent. was removed on the surface of the filter than with floc from sodium aluminate, under the conditions operating at the time of the test.

16. The effective size is more useful in comparing filter sands than it is in comparing sands of widely varying characteristics. With similar grains, per cent. of voids, and a comparatively small range in grain size,

the effective size gives nearly as good results as the surface modulus or specific surface, but with dissimiliar sands this is not the case.

Some of these conclusions are restatements of facts that have been presented before by other investigators, and the present investigation but adds additional evidence in their favor. The last statement in this summary, however, warrants further remarks. Dr. Terzaghi recently stated that in his opinion the mechanical analysis of sands or soils was far from all that could be desired as a means of defining the material or predicting its behavior under given conditions. The tests that have been made and are now in progress at the Institute, appear to bear out this statement, and any factor which depends on a sieve analysis for its determination cannot, from the nature of the case, be entirely satisfactory. This applies to the effective size, uniformity coefficient, and surface modulus. The latter, however, has the advantages claimed in a former paper,[6] resulting from the greater ease and accuracy of its determination and from its greater consideration for all of the sand sizes, but this advantage is only relative.* The specific surface has the further advantage of including the effect of compactness. As yet no satisfactory method has come to our attention for determining the true specific surface, for the shape of grain should be taken into account, while in these computations they were considered as spheres. In rating the sieves, grains passing each sieve were measured with a microscope along their three principal axes so this variation could have been taken into account. But irregularities of surface are too complex to be determined in this way.

It appears that the important facts to be determined in regard to a sand are the shape of the grains, the total and individual volume of voids in the material in place, and the character of the surface itself. These items are not measured by the sieve analysis though such an analysis is helpful, as above pointed out, in comparing similar materials, as, for example, filter sands. What is needed would appear to be, not so much an increased refinement in the present methods of analysis, but some other method of analyzing the sample so as to measure either directly or indirectly the characteristics concerning which information is desired. Such a test should be capable of measuring some function of the size, shape, and smoothness of the grain and the compactness of the mass as a whole. The specific surface includes all of these, even smoothness being a matter of surface irregularity. A permeability test measures these variables better than other tests now in use, but such a test is much more difficult to make than the

*The surface modulus as defined in the paper referred to, is a factor which, when multiplied by a constant dependent upon the smallest sieve size used, is equal to the surface area of one gram of the sand, the grains being assumed to be spheres.

$$\text{Surface Modulus} = P_1 + \frac{P_2}{i} + \frac{P_3}{i^2} + \cdots \frac{P_n}{i^{n-1}}$$

where P_1, P_2, etc., =percentage retained between adjacent sieves, beginning at the finest, and i =sieve interval or ratio for the series used.

The specific surface is equal to the surface area of one cubic centimeter of the sand with voids as found in the sample in place. Here also the grains are assumed to be spherical.

sieve analysis and there are more possibilities of error in its performance. Possibly a test to measure the capillary characteristics, which are functions of the same variables encountered in its permeability, may be as specific as a test of the latter function, while having the advantage of greater ease and simplicity in its performance, as suggested in a former paper.[6]

The writers wish to acknowledge their indebtedness to Mr. Timothy W. Good, Superintendent of the Cambridge Water Department, Prof. M. C. Whipple, who supervises the operation of the plant, and Mr. Harold C. Chandler, chemist at the plant, for their coöperation in making the investigation possible; and to the latter two for many helpful suggestions and for information in regard to the operation of the filters. The other employees of the plant also rendered much helpful assistance in carrying out the tests.

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[3] "On the Flow of Water through Rapid Sand Filters," by C. N. Miller. Appendix A., Ellms' Water Purification, 1917. McGraw-Hill Book Company.

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[5] The formula of Dr. Terzaghi is:

$$k = \left(\frac{C}{V_o}\right)\left(\frac{V_o}{V_t}\right)\left(\frac{n-0.13}{\sqrt[3]{1-3}}\right)^2 d^2$$

Eng. News-Record, Vol. 95, p. 832.

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PURPOSE OF THE CAST-IRON PIPE PUBLICITY BUREAU.

BY THOMAS F. WOLFE.*

The makers of cast-iron pipe are in a somewhat unusual position in the business world. When cast-iron pipe is purchased for a water or gas distribution system, it is known in advance that the pipe will be in service, in all probability, for at least 100 years. The only additional business that can be expected from any customer, however well he may be satisfied, is the pipe for additions or extensions to the existing system.

It therefore became apparent to the manufacturers, that the market for the product must be developed if a satisfactory volume of business was to be maintained.

With a product so thoroughly standardized as cast-iron pipe, the cost of developing this market through the individual advertising efforts of the various companies was plainly prohibitive. After a product has been in use for upwards of 250 years, its merits are rather clearly understood. Any advertising which might be undertaken would necessarily have as its chief element the constant presentation of the advantages of the use of cast-iron pipe.

It is significant that several of the pipe makers who ultimately cooperated to form the Cast-Iron Pipe Publicity Bureau were investigating the problem of advertising at the same time. The plan was suggested that, due to the nature of the product, the needs of all the manufacturers could best be served by advertising the product as that of an industry, rather than as the pipe made by particular companies. At a meeting of the pipe manufacturers, this idea was considered and the Cast-Iron Pipe Publicity Bureau was formally launched.

In addition to the joint publicity work, it was agreed to establish a central office in charge of a water-works engineer — this central office to handle all inquiries and to handle the technical questions which might be asked concerning the product or refer the inquirer to a consulting engineer, in case the matter should properly be so handled.

During the first few years of its life, the advertising efforts of the bureau were confined to advertising the merits of cast-iron pipe in the engineering and trade journals. This advertising, while effective, was addressed to water-works and gas men, many of whom had learned from experience all that the most ambitious copywriter could hope to tell them. Specifications for cast-iron pipe had been prepared and adopted by the New England Water Works Association, American Water Works Association, and the American Gas Institute,— later the American Gas Association,— many years prior to this time.

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Singing the praises of cast-iron pipe to the men who had prepared these specifications and who had worked with it all their life, while important, was not broad enough to meet the first aim for which the Bureau had been organized — that is, to increase the market for cast-iron pipe. Therefore, publicity in national magazines was decided upon as the most effective means of broadening the market for cast-iron pipe, and an advertising agency retained to handle the work. The way in which this was accomplished will be dealt with later, but it is significant that the *Literary Digest* — the medium selected — has twice in the last year produced, for its own promotional work, two booklets based on the advertising of the Cast-Iron Pipe Publicity Bureau. The titles of these books are significant:

(1) "This Folder contains a Complete Exhibit of Great Interest to Those Who are Some Day Going to Advertise Nationally" and (2) "A Story of Civic Progress and How It Pays to Advertise to the Ruling Classes."

With the use of this publicity, the value of the central bureau office in charge of a water-works engineer became increasingly apparent. A host of questions immediately developed from people who were eager to learn more about water works and who needed only to be guided in the right direction to secure this greatest of all benefits for their communities and, at the same time, accomplish the bureau's aims of promoting a greater market for cast-iron pipe.

As this work has progressed and as the publicity program has developed it has divided itself into four definite headings:

1. Promoting the construction of new water works. This work, of course, applies only to communities not equipped with water works at the present time. After locating such communities and, more important still, locating the citizen in those communities who was interested, the bureau offers every assistance to bring about the building of water works.

2. Encouragement of proper design of water works. This work also divides itself into two phases, the first of which deals with towns that are about to install water works. Through its publicity and, more particularly, through the follow-up work from the bureau, there has been brought to the attention of these communities the great necessity of first using the proper materials, so that their water-works system might endure for many years without need of repair or replacement, and, second, to build it of a size that would provide for future growth and, third, to install a distribution system that would provide proper fire protection as well as water for home and industrial use. The other function of this phase of the publicity has been to arouse the public interest so that improperly designed water works, or water works that have been outgrown by the community, may be rehabilitated.

While this has been an important part of the bureau, its accomplishment has been relatively easy. It seems that there has been, in times past, a tendency to construct water works as cheaply as possible, even at the expense of adequacy of water supply. In some cases, water works have

been built without regard for the fact that the use of improper materials meant the gradual failure of the system and the ultimate necessity of replacing it almost in its entirety. These improperly designed plants were usually of little concern to the water user, until the lack of water made itself painfully apparent. The citizen was then inclined to blame the water-works department, but hesitated to vote the bonds necessary for the rehabilitation of the system.

3. Therefore, a certain part of the work of this bureau has been to urge the private citizen to take an interest in his water supply, so that he would realize the necessity for replacing the pumps that were too small in size, and hence that had been outgrown, due to the growth of the community or, in cases where inferior material had been used, the need of replacing leaky mains.

This phase of the work has been very effective. The citizen has seemed to take it in good part and very frequently the water-works official has requested reprints of these advertisements to use in his own town.

4. The fourth and last effort of the publicity work — that is, of increasing the market for cast-iron pipe — has been to point out the advantages of cast-iron pipe. This, however, has been done only occasionally, and more or less incidentally, as the opportunity offered, as it has been found to be good business to subordinate it to the necessity for adequate water supply.

Posters.

In addition to the magazine advertising, the bureau has made extensive use of posters designed particularly for towns considering water works or for use in campaigns for bond issues or prior to voting on water works in these towns.

These carry no advertising whatever, simply the slogan, "Why not a Water Works in our Town?" combined with pictures that bring to the attention of the public the inconvenience of the pump as compared to running water, and that point out the danger of fire and the inadequacy of the bucket brigade.

These have proven an effective aid in many campaigns for water works in small towns and are furnished without charge by the bureau to citizens, chambers of commerce, and other civic clubs for use in promoting water works. Together with these, the bureau has undertaken to supply outlines for campaigns and has put the inquirers in touch with their state health service and state water service in the States which have such services. The bureau has also furnished many suggestions for the conduct of campaigns and has carried water-works advertising in the towns involved during the campaigns.

This service has never been restricted but has always been freely given to anyone requesting it. In a number of cases the bureau has furnished this material and suggestions to consulting engineers who were interested in securing water works for some town.

The bureau has never felt that questions concerning the particular design or construction of a water-works system were a part of its work. The bureau coöperates fully on all questions of what might be termed "Campaigning for Water Works," but on all questions involving engineering work, the location of water supply, preparation of plans, etc., the bureau impresses upon the enquirer the necessity for handling this work through a consulting engineer, who would be in a position to make an examination of the project under consideration. In these cases, the necessity of retaining an engineer is urged upon the citizen asking advice, and the economy of spending money on proper design and consulting service is always pointed out to him.

This is felt to be a most important part of the work of the bureau, for however much it is desirable to encourage the building of water works, it is equally important to discourage the building of a water works designed by a layman or a local plumber. Such projects are very apt to give the whole question of water works a black-eye in the vicinity of the plant so designed, as it can seldom be expected to give other than unsatisfactory service.

Another phase of the work of this bureau which has proved helpful to the industry in selling pipe and also, it is believed, has added to the fund of information of the water-works profession as a whole, has been that of collecting data. This work has divided itself into two phases: (1) Data on the advantages of cast-iron pipe, (2) Data on pipe failures.

Some of this information has been dug out independently by the bureau itself and a great deal of it has come through the cheerful coöperation of men using cast-iron pipe in water-works systems or in gas distribution systems. Through this coöperation of water-works and gas engineers, much information has been collected and disseminated by the bureau either in the form of advertising or publicity prepared for trade papers. In fact, those of you who have seen advertising of the Cast-Iron Pipe Publicity Bureau in your trade periodicals have doubtless noticed the advertisements that have appeared from time to time during the past two years on three subjects of great importance to the water-works engineer: (1) Tuberculation and its effect on carrying capacity; (2) The enormous cost of repair under paving, and (3) the corrosive effects of modern city soils.

While an advertisement on each one of these subjects might have been considered a justifiable contribution on the part of the Cast-Iron Pipe Publicity Bureau, the extensive use that has been made of each of them in our advertising and publicity work has proven that in our trade paper advertising, service to the industry is our greatest selling appeal, and that those facts which bring out the service that may be expected from cast-iron pipe make up publicity best calculated to secure its greater use.

Data on Pipe Failures.

Another service of the publicity bureau, while it may not be so readily apparent and may lack the spectacular elements of some other phases of the

work, has been the study of pipe failures. This bureau has constantly made an effort to study every case of pipe failure that came to hand, and no corner of the United States was ever too remote to go to if it were reported that a pipe line was being dug up, due to failure in service.

Some of these pipe-line failures, of course, occurred in lines of cast-iron pipe, and the bureau immediately reported these to the manufacturers, sometimes with suggestions by which often, when it was found that the break was due to natural conditions or improper laying, the bureau has taken pains to broadcast the corrective practice which might be expected to eliminate such breaks in the future, at times even going so far as to circularize the entire industry on this very important subject.

The data on pipe failures, when the pipe was composed of other than cast iron, has given the member companies considerable insight into what might be expected from these competitors, but the bureau has always refrained from drawing any such comparisons or reporting any such instances in our publicity. It has always been felt that cast-iron pipe was a material which could stand on its own merits, without dwelling upon the demerits of other materials which might be used as substitutes.

Technical Committee.

An important development of the work of the bureau, and one somewhat aside from advertising, has been the formation of a technical committee to deal with engineering matters pertaining to the manufacture and use of cast-iron pipe. This committee is composed of engineers in the employ of the various pipe companies, men familiar with the use of pipe as well as with its manufacture and, consequently, in a position to harmonize the needs of the pipe user with good pipe-shop practice.

As an example of the work of this committee, a standard specification has been prepared by them for cement-lined cast-iron pipe. This specification is the result of study of the thickness of cement required to prevent tuberculation, ability of lining to withstand shocks incident to handling pipe, and the feasibility of applying the lining in the shop. The resulting specification has been found quite satisfactory and it is hoped that before long it will be adopted by the major Water Works Associations.

A second work of this committee is the preparation of a handbook on pipe. This book, which is about ready for the press, will include chapters on the production of iron, pipe manufacture, pipe-laying, specifications for pipe, as well as sections on gas pipe, flanged pipe, and other special types of pipe.

That, briefly, is a résumé of what the Cast-Iron Pipe Publicity Bureau set out to accomplish and what it has accomplished in promoting a better understanding of water works and a better understanding of the use of cast-iron pipe, and the response which has been obtained has certainly justified the founders of the bureau in their undertaking.

It would be interesting for a few moments to study the appeals that have been used in this advertising, especially those addressed to the general public. When the national publicity was first undertaken, the question was studied and it was decided that there were four major appeals:

(1) Fire protection.
(2) Health.
(3) Convenience in the home.
(4) Developing the community.

Which of these appeals would be best calculated to arouse the interest of the citizen and voter? Five years ago, we would have said, obviously, that these appeals would be valuable in about the same order as just stated — that is, (1) Fire, (2) Health, (3) Convenience, and (4) Growth; but over this long period of years, in which results have been very carefully checked and charted, it would seem that a man is willing to take a chance on his property being destroyed by fire and pay the higher insurance premiums that inadequate fire protection always brings; that he is really not vitally concerned about his health, and that he believes water from his private well is the best water in the county. He is mildly interested in whether or not his community grows. But — when our advertisements start to talk about the labor of pumping and hauling water for domestic use, and pointing out that this is an unnecessary hardship, the desire for water works immediately breaks out all over the United States.

An analysis of this situation points to the fact that most agitation for water works is probably started by women, and advertisements which have been written with this point in view have never failed to bring results. While those of us in industry and public work may regard fire as a great source of national waste, and ill-health and epidemics as a scourge to the nation, it is obvious that to the small town resident, especially the women, the inconvenience of the lack of running water is a far greater annoyance. It is apparent that the thought of escape from the drudgery of daily bringing water from the well, and the Saturday-night kettle of hot water, needs but to be touched upon to bring an instant response.

While the bureau has never overlooked the other appeals, experience has certainly shown that convenience is the greatest one, and this same idea has always yielded superior results when used over and over again.

It has also been found that the advertisements addressed directly to towns not having water works have produced responses in greatest volume and it is also interesting to note that practically these same appeals directed toward the towns which have inadequate water works have brought corresponding response in about the same relative volume. The advantages of better fire protection can also be stressed in this advertising, as it has become more important to these towns, probably because they are larger and see more of the need for it.

It has also been found that, to a large extent, we have reached a great

many of the towns that are lacking an adequate water works through the medium of the advertisements which are addressed to towns having no water works at all, bearing out the theory that the pain of inconvenience is acute.

In many of the advertisements that we used there is a constant recurrence of an appeal to the small town. This again is deliberate and has been found to be the best result producer. Its use might be said to be a matter of technique, as it has been found to be the best possible approach to secure the reader's interest in advertising. In charting the number of inquiries, it is evident that there is a series of peaks and valleys that represent our education in extending the use of water-works systems. It is significant that these peaks follow the appeals outlined heretofore, but most important to the cast-iron pipe industry and to all of those interested in the advancement of water works is the fact that both the appeals and the results show that our progress has been not in the cities where most people go for an increase of business, but out on the highways and byways — in places that a salesman never heard of, and an engineer never visited — in the small town — there has been found and is constantly being developed a new and broader market for cast-iron pipe and, incidentally, for water-works systems.

This bureau is proud of the results obtained and feels sure that this pride is justified. But a great portion of the credit for success of the work is due to the fact that it was done coöperatively by the manufacturers of cast-iron pipe. The advantages of unified action and unified presentation have given this advertising far more force than could have been expected from individual efforts. We also believe that it has rendered a service coming from a united industry that has been of considerable benefit to many towns and cities in America and to the water-works profession as a whole, and to whom, in turn, we render our thanks for their cheerful and able coöperation on many occasions.

COMPENSATING RESERVOIRS AND DIVERSION OF WATER.

BY CALEB MILLS SAVILLE.*

[*Read September 15, 1926.*]

"The old order changes, giving place to new, and God fulfills himself in many ways lest one good custom should corrupt the world."
"The Passing of Arthur." — Tennyson.

Under the old "Mill Acts," differing but in phraseology in the older industrial states, the right of industry to develop power from falling water was recognized as paramount, and private land ownership gave way before the need for the common good.

The need for the common good still persists and is an eternal principle, but the methods of serving that need, while changing almost imperceptibly from year to year, in the march of generations are so altered as to seem almost a reversal of the former law of conduct.

Nothing, however, is lost; things merely alter and change their shape, as the law of conservation of energy tells, and if we are content to look on with an open mind unprejudiced by personal or selfish thought it is probable that we may see the vision and the more readily adapt our methods of overcoming seeming difficulties.

The change in industrial conditions within the past decade, calling for shorter working hours and utilization of dependable peak capacities, has inevitably left its mark on the methods used and the results desired in settling or adjusting claims for damage due to diversion of water used for power.

The viewpoint of the law also has changed in a marked degree during the past third of a century. In the earlier day property interests were paramount and to disturb them for any cause whatsoever was almost criminal procedure. At the present time the personal right and comfort of the individual or community is securing such consideration as to be almost revolutionary. The spirit of conciliation and coöperation also is abroad, in place of the arbitrary court decision which often left a most bitter feeling behind.

Methods of utilizing power, transportation of fuel, and transportation of power itself for long distances, have so changed the old standards of valuation that they no longer can be depended upon for just comparison for settlement.

It is the purpose of this paper to call attention to some of these changes, to recall some of the earlier settlements, to remark on some of the more recent methods, and to suggest a method which, it is hoped, will be of

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material advantage both to power users whose interests are interfered with and to the community whose interests must be served.

The problem is not one of pure mathematics, power engineering, or social welfare. It partakes of these considerations and of many others, but in the last analysis the solution must be found in the ultimate good of the community, and judgment must be based on equity and law.

The basic question now, as in the past, is, what is equity, and the present conception thereof appears to be vastly different from what it was 50 years ago.

At the outset, it seems desirable to bring out a fact that is too often lost to sight in seeking reimbursement for damages from diversion of water for municipal purposes from a stream utilized for power or other uses; that, except in exceptional cases, the matter is one of corporation against corporation, or of individual against a corporation seeking only restitution in money or otherwise, for the rights and property that are to be taken away. Too often this phase of the matter is overlooked in the pathetic or accusing eloquence that seeks to picture the municipality in the attitude of a timorous traveller set upon by highwaymen seeking to rob him of his rights. The fact is lost sight of that years before there was any dream of a vast population that would be requiring millions of gallons of water for its daily use, enterprising men established mills on these streams which were then in the wilderness, built villages, gathered stable and industrious employees, and built up a community which enriched itself as well as made returns to the organizer of industry. In many cases this industry itself is the foundation of some community thriving because of the industry and obliterated if the industry is destroyed or seriously injured by external causes.

In problems between the individual and the city it is well to remember that not all the virtue is on the side of the municipality and that many an injustice in settlement has been committed because of unlimited resources in the common treasury disbursed by officials handling public funds as opposed by limited capital of the individual. Happily, however, this attitude is passing, and real values are now often given for sentiment, good will, and intangible injury to individuals; and fair and equitable adjustments are proposed for corporation rights.

In settlements for damages from diversion of water the term "fair market value" continually occurs. What is "fair market value?" Lewis on Eminent Domain says: "The market value of property includes its value for any use to which it may be put. If by reason of its surroundings, its natural advantages, its artificial improvements, its intrinsic value, it is peculiarly adapted to some particular use, all the circumstances which make up this adaptability may be shown, and the fact of such adaptation may be taken into consideration in estimating compensation."

In the diversion of water from a stream there are many other things beside abstraction of power to be considered. In some cases the water

may be worth even more for purposes of washing than for power. It may be that the abstraction of a certain amount of water will leave so small an amount running in the stream that it would be unprofitable to use this remainder for power, or the pollution above, which before diversion was too small in amount to be of detriment, after the diversion may be so great a proportion of the remaining flow of the stream as to render the stream unfit for process uses.

Now while the water itself flowing in a surface stream is not and cannot be the property of any man or corporation, the use of that water for personal advantage is an inalienable property right, and if the element which produced that advantage is abstracted or tampered with to the extent of diminishing that advantage, personal rights have been invaded and private property taken for which just compensation must be made.

The courts of the United States have held that "just compensation" means value in terms of money payment, and this is often a hard problem to solve. There are often cases where money equivalent is impossible of computation.

In England damage to property on account of water diversion is ordinarily settled by "compensation-in-kind" so called, that is, by supplying some amount of water in place of that diverted. What this amount shall be is arbitrarily established by Act of Parliament.

As to these two methods, — that in America by money payment and that in England by compensation-in-kind, — the latter seems the more logical as a general proposition, but its present method of application appears to have defects that could well be corrected. These defects are recognized by English practitioners and much careful thought is being given to this matter by able water-supply engineers.

In the determination of damage from diversion of water in America, one of the first and usually most controverted questions is to establish what is known as the "fair market value" of the property taken or damaged.

At the outset, it is pertinent to state that there is no such "animal" as fair market value, and it is almost as absurd to endeavor to ascertain what is that illusive thing, known as that value which a willing purchaser will pay to a willing seller for a piece of property, or to get down to "brass tacks," as it were, an interest in an intangible something known as a water right. No man living knows what is the actual value of a location where a water power may be developed, and any value placed upon such a location must be a compromise between the optimistic illusions of the present owner and the ultra-conservative judgment of a possible purchaser if he has sound business sense.

Damages to present water privileges by diversion are real, but to attempt to compute the exact money value even of that damage, by mathematical formula or by definite rules based on experience elsewhere, is to court a ridiculous conclusion.

Sales of property in the vicinity furnish an interesting sidelight, and

settlements elsewhere for similar damage to similar property are illuminating, but the intangible something that pertains particularly to each individual property is a factor which most often bars the way between probable purchaser and possible seller.

The water right owner, however, cannot stop that march of progress that requires for municipal uses water flow that has been utilized by him and his predecessors for years. Oftentimes he would not stop it if he could, but the taking of that flow even in part may cause him irreparable damage in lessened power, in changes in water characteristics, in readjustments in labor conditions and in severance damage to his plant which can never be made over to produce as before.

But how compute the money value of the property damage so that both the mill owner and the municipality may be fairly served?

The basic formula is: find the money value before and after diversion and capitalize this at a fair rate. Fifty years ago this method had much more in its favor than at the present time. Then industries were more firmly established and the cloth or shoes or machine bolts were staple goods. Today industry is moving with such rapid strides to keep up with modern requirements that it is hard to say what will be the value in income from plant operation within the next five or ten years when the means of output are not sufficiently flexible to meet conditions as they come.

Power to be of use to manufacturing plants of any magnitude must be available the whole year, at such times as it is needed. The flow in unregulated New England streams is not of constant quantity but varies with the seasons. To make water power commercially useful the development must require only the lowest flows of the year, or auxiliary power from some other source must be available to supplement stream flow up to the limit of power requirements. From these statements and a glance at the tables of yield of New England streams herewith presented, it is readily seen that a critical point may be determined above which it may be uneconomical to install auxiliary power for supplementary use, i.e., the cost of installation of the amount of auxiliary power required may make it desirable to use such power the whole time and not make the water-power investment. Each case, however, is a law unto itself and must be decided on its own merits in view of local and business conditions. These conditions, however, are a logical argument for compensation-in-kind as against money payment in providing the more reasonable method and one of better advantage to industry in the handling of diversion matters, i.e., avoiding injury rather than wilfully causing it and settling thereafter on a money basis.

The endeavor, of course, is to ascertain as nearly as possible the amount of damage by the diversion, represented by the difference in cost of producing the amount of power obtained at the given plant before diversion, properly supplemented so as to give a steady power the year round; and the cost of producing the same total amount of power after the

diversion. This difference in cost, capitalized at a proper figure (about 5 per cent. at the present time), gives the amount of damage to developed and going installations. The value of unused or undeveloped privileges is usually purely speculative, and purchases of similar property, if available, give the best guide for negotiation.

In addition there are losses from severance of a portion of a complete plant which it may be impossible to replace in this manner, i.e., the portion of the theoretical power remaining after diversion may be too small to warrant continuance. Again there may be uses for water in industrial processes that cannot be continued after diversion on account of changes in physical conditions of the remaining water, making it unfit for its former use.

Recently in passing through a section of northern New York, a practically deserted village was reached. Here was dwelling after dwelling entirely empty, the village store was closed, the railroad station was falling down, the hotel or boarding-house was vacant and with broken windows, and the church was ready to give up. The cause of this was ascertained to be due to the change which a nationally known sugar-refining corporation had made in using bags instead of wooden staves in which to ship its product. This village was formerly a headquarters for making these staves. Coming nearer home there are several mills on the lower Farmington River and other small streams in Connecticut that were prosperous makers of woolen goods a decade or so ago, but are now vacant, due to a combination of several causes; maybe the younger members of the family no longer care to carry on, maybe styles and requirements have changed. Nevertheless the water rights are there, the fall in the stream is the same, the rainfall yields the same amount to the stream. What is the fair market value of these powers?

On the other hand, on this same Farmington River there were two old paper mills, one abandoned and the other nearly so, both of which were served with power from a joint dam with 10-ft. fall. A short distance upstream was an electric power plant with a dam 20 ft. high, and its business in not too flourishing a condition. A well-known manufacturing company purchased the right in both dams, erected a modern dam in the place of the original two, and utilized 58 ft. fall for developing the output from a 10 000 K.V.A. installation sending the current 18 miles overland for use in their industrial plant.

Changed conditions in power production seems to be one of the most potent causes underlying the disuse of these comparatively small powers. Perhaps we are now in the trough of the wave of demand for this class of power and possibly 10 or 15 years hence these small and disused powers will be sought out, linked up by the marvelous electrical development of this century and, as Steinmetz foresaw, will again come to their own in a chain of small units feeding into one trunk transmission line that will supply industry at some more accessible point.

But money value based on capitalization at some accepted rate is not a fair method of compensating for damage to such plants or even to others which may in a short time find themselves in the same class.

It is not fair to the owner, for in a few years his water privilege may become of much greater value due to changed industrial conditions. It is not fair to the purchaser or municipality because it establishes a fund in which there is no risk for the owner, whereas heretofore he had all the risks of business.

The most equitable method of settlement for diversion of water, whether used for power or process or both, is by compensation in-kind by methods that will simulate as nearly as may be the natural usable run-off of the stream which is taken away.

Such a method, if properly pursued, will leave present riparian owners in exactly the same condition as at present, with all the rights and privileges that they have reasonably enjoyed before the diversion; it will conserve energy and water now running to waste and will lighten the burdens of the courts and the expenses of litigation at present arising from the erection of the hypothetical framework now used on which to hang the oftentimes spurious argument, that the contending parties use in defending their several theories of probability.

The run-off of two streams is never exactly alike even over a term of years, and the same stream never repeats its run-off either in volume of water discharged or in relation to rainfall upon its drainage area. Nearly 15 years ago a classic report* relating to "Awards for Water and Water Power Diversion," was submitted by a committee of this Association, composed of some of the ablest hydraulic engineers of this country. Since then its data and conclusions have been standard in matters relating to this subject.

At that time and prior thereto the basis for settlement was almost entirely referred to performance of steam plants, and stress was usually laid upon the unreliability of water power, its intermittent or partial utility, and the necessity of usually having stand-by steam plants. In this report it is stated as the consensus of opinion at that time that the wheel development of the water-power privilege ordinarily corresponded to the yield of the watershed in the seventh month, arranged in order of dryness.

How conditions have changed even in the short period since this report was published need only be indicated by the hydraulic installations now being constructed to take the peak flows of the streams, leaving the low run to be augmented by steam auxiliaries located at tide water where cheap fuel is available. All this is possible through the marvelous network of high tension electric lines connecting station to station, drawing here and delivering there so that there is neither surplus nor deficiency, and industry proceeds at a uniform pace, sure that its needs will be met as required.

With this change in transformation and utilization of energy has come

*JOURNAL, N.E.W.W.A., March, 1910.

a revolution in methods of evaluating potential power, and ways must be found to keep the balance between just compensation and excessive cost of acquirement.

This also is a period of conservation and endeavor to prevent waste of all kinds. Any suggestion having for its object such a result is worthy of consideration. Water, of course, is the prime essential of life on the planet on which we live. Only so much of this necessity is available, and its utilization must proceed under more or less strict regulation.

Beside its use for potable purposes, consideration must be given to its employment in industry as a means of waste disposal, and as a very great adjunct to the health and happiness of people in the means that it affords for sport and recreation.

In the northeastern states, particularly, the flow of water in the streams is not by any means uniform throughout the year. The yield of the Wachusett watershed of the Boston Metropolitan Water Supply at Clinton, Mass., for the 29 years of record, 1897–1925, well illustrates this condition.*

Month.	Average cu. ft. per sec. per sq. mi.	Average rainfall, inches.	Rainfall collected, inches.	Per cent. collected.	Order of dryness.
January	1.806	3.69	2.082	56.4	8
February	2.031	3.76	2.131	56.7	9
March	4.096	4.10	4.724	115.3	12 wettest
April	3.452	3.93	3.852	97.9	11
May	2.040	3.35	2.352	70.2	10
June	1.262	3.88	1.408	36.3	6
July	0.737	4.13	0.850	20.6	3
August	0.607	3.94	0.700	17.8	2
September	0.547	3.70	0.610	16.5	1 dryest
October	0.695	3.15	0.802	25.4	4
November	1.175	3.62	1.311	36.2	5
December	1.799	3.99	2.075	52.0	7
Year	1.686	45.24	22.897	50.6	

From this tabulation it appears that the flow in the seventh dryest month is not far from the average flow of the year and only about 45 per cent. of that of the wettest month of the year. That is to say, under the old method of utilization for at least five consecutive months nearly quite as much water flowed over the dams and was lost as was retained for useful effort throughout the year.

Reference has been made above to the English method of compensation-in-kind for water taken from the stream for purposes other than those of riparian owners. In this practice it is the custom to compensate riparian owners for water diverted from a stream by providing by Act of Parliament for an arbitrarily determined constant flow. Usually this amount is about one-third of the rainfall of the three dryest consecutive years.

*Reproduced through courtesy of Mr. W. E. Foss, Director and Chief Engineer.

In arriving at the amount of "available water" about 78 per cent. of the long period average rainfall is taken and from this is subtracted the estimated yearly loss by evaporation, absorption, plant transpiration, etc., amounting to about 14 inches. Of the remainder, called "available water," about one-third is sent down the stream day by day as compensating water.

Compensation water thus allocated is often much in excess of the natural dry-weather flow of the stream, and therefore this practice usually results in much detriment to the water works in maintaining this constant flow throughout the year while, on the other hand, the riparian owners are usually greatly benefited by the act of diversion.

In the case of no manufacturers being affected on the stream, it is usual to recognize fishing interests by giving compensation to the amount of one-quarter or less of the "available water," and in such cases some money compensation also is usual.

In English practice up to the present time compensation water has been measured in terms of rainfall rather than in flow of stream and, as stated above, certain arbitrary rules are in force to apportion the amount of rainfall that is to be considered as compensation. Why the name "compensation" should be applied to this remainder is not quite clear, or that a riparian owner should be obliged by law to receive a portion of the river flow in lieu of the whole amount that was his previous to diversion, although the intention undoubtedly is to allocate for domestic uses certain waters which now have no useful purpose and to leave in the stream a sufficient amount to reasonably satisfy riparian needs.

The American method of compensation, based on actual stream flow of the same or similar streams, seems far more logical than the English method based on a compensation which with our present knowledge has little or no relation to the incidence of stream flow. The reason for the English method may probably be found in the fact that there are many long-term rainfall records available over nearly the whole of England, whereas run-off records are comparatively scarce and of short-term periods.

Again, precedent has a great hold on English practice, and the fact that the method of establishing the amount of "available water" was originated some 75 years ago by Mr. Thomas Hawksley is sufficient in itself to forestall most arguments as to its inefficiency or illogical results.

It has been proposed* that the average flow of seven or eight years during the driest period of the years, usually about 14 days, be taken as the normal dry-weather flow, and that this figure be taken as the basic figure for compensation which, when multiplied by a factor obtained from the proved claims to water of mill owners, may more readily give compensation than the present method. While this seems a logical method so far as power is concerned, there appear to be many difficulties in the way of perfect accomplishment. Mr. Macaulay recognizes the limitations of this

*Relation of Compensation Water to Stream Flow (England), by F. W. Macaulay, M. Inst. C.E., Feb. 21, 1922, p. 15.

suggestion and others, to general application, and states "it cannot be stated too strongly that no hard-and-fast empirical formula, other than one for finding the basic figure for each stream, can possibly be found to give satisfactory results all over the country . . . and each case must be taken on its own merits."

A serious detriment in the application of too much regulation of the stream flow is found in diminishing the scouring effect of the floods in washing out the deposits of filth that accumulate in stream beds during periods of low and even normal flow if waste discharges are considerable. These deposits are removed by the sudden rushes of large volumes of swiftly moving water produced by the spring freshets, but if these are too considerably modified by regulating works there is a tendency toward permanent fouling of the river, and this may in time become unbearable.

This phase of the matter has been carefully considered in English practice and oftentimes the diverting interests are required to store a portion of the average daily flow during a prescribed period and to discharge the water thus accumulated within a limited time. The object is to create artificially a small flood, or spate, to cleanse the stream. Evidence, however, before the Water Resources Committee of the English Board of Trade, has failed to establish the general efficiency of this proposition.

In considering the relative merits of the English method of compensation-in-kind and the American method of cash payments, a favorable feature of the English practice is the elasticity by which water allocated at one time for riparian compensation may, if this need lapses, be reallocated for diversion purposes, where under American practice the money paid is gone forever.

Between the American and English practice there seems a subtle distinction between a vested right and a usufruct, which it is hard to bridge.

As intimated above, however, this method of compensation in kind appears to have good points and it seems probable that some modified practice based upon it might be worked out advantageously both for diverting and riparian interests.

In the development of its additional supply a compensation-in-kind adjustment was agreed upon by the city of Hartford and the mill owners. This has now been in force for five years and has worked in a very satisfactory manner to all concerned. Not the least of the causes for this condition, however, has been the very amicable spirit of coöperation evinced by all parties.

The following data are submitted for the purpose of comparing cost of awards and money settlements for diversion with cost of compensation-in-kind.

Compared with most of the settlements reported by the Committee of this Association in 1910, the cost of compensation seems rather high. Compared with some recent settlements, the method pursued appears very

satisfactory so far as money expenditure is concerned. It is, however, pertinent to state that direct comparisons, without detailed knowledge of all the facts, are worse than misleading and can seldom be depended on except as a very rough guide for basing judgment in individual cases.

In the present case, two of the largest powers lost nearly 10 per cent. of their tributary area on a very flashy stream, which at times, for considerable periods, would furnish only from a fifth to a tenth of the installed capacity of the wheels. With this in mind it can readily be appreciated that the claim of "irreparable damage" might have some justification, especially when these mills stated that it was water and not money damage that they desired, a statement borne out by subsequent developments at most of them.

Authority was sought from the State Legislature in 1909 to divert the water of the Nepaug River, a tributary of the Farmington River at Collinsville, about 18 miles northwest of Hartford. The Farmington River, taking its rise in Massachusetts, flows in a general southerly and easterly direction and discharges into the Connecticut River a few miles north of Hartford. The Farmington River is a very highly power-developed stream, having on its course many diversified and long-established industrial plants. The owners of these plants, although recognizing the needs of the city of Hartford, nevertheless found it necessary, although in most cases reluctantly, to oppose the original application for the taking, and were successful at this time. The Legislature of Connecticut meets but once in two years. Before the session of 1911 was convened, the plan for a storage reservoir had been worked out with an earnest endeavor on all sides to reach a satisfactory solution, by Messrs. Allen Hazen and John H. Cook acting, respectively, for the city of Hartford and the mill owners on the stream. As there were then no run-off data available from the stream in question, the run-off records of other streams in this section of the country were used and a reservoir of 3 million gal. capacity, located somewhere on another large tributary of the Farmington River, was proposed and accepted. When the Legislature met in 1911 the mill owners had withdrawn objection and the Legislature ratified the agreement previously made for the compensating reservoir in lieu of the diverted waters. The majority of the power interests signed an agreement with the Water Board to accept the compensating reservoir plan under certain conditions to which the Board agreed. Others did not sign but stated that if the compensating reservoir compensated as expected, they would be perfectly satisfied and would not object. One or two small owners were unreconcilable but have never had the courage to attempt to prove damage. Today, I believe that all of the power users are convinced that their water conditions are improved over what they were prior to the construction of the compensating reservoir.

Two landowners, setting a very high price on their land which was needed by the Water Board in the construction of this reservoir, took court action against condemnation proceedings by the city and ultimately carried

the case to the United States Supreme Court where judgment was rendered against them and the case closed with payment for the land taken.

The grounds for court action and appeal were based on the question of constitutionality of the act of Legislature which allowed private property to be condemned for compensating reservoir purposes instead of requiring the city to make money payment for diversion damage to riparian owners. The ground for favorable decision by the courts on behalf of the city was the utilization of waste waters for a public use. Among the citations applicable to this question, Lewis on Eminent Domain (Sec. 254) states: "It is not necessary that the entire community or any considerable portion of it should directly participate in the benefits to be derived from the property taken. The public use required need not be the use of the benefit of the whole public or state or any large part of it. It may be for the inhabitants of a small or restricted locality, but the use and benefit must be in common, not to particular individuals or estate . . . . If the use is open to all, upon equal terms, who are so situated as to be able to enjoy the privilege, it is immaterial how few actually avail themselves of the right. The amount of benefit to be determined from a particular improvement or system of improvements is a consideration which addresses itself to the Legislature and not to the court."

In the argument for the Board of Water Commissioners, counsel said: "We respectfully submit that this court should recognize the fact that municipalities have grown in this state very rapidly in the past twenty-five or fifty years; that it is becoming more and more a very difficult problem for these municipalities to secure water for their needs; that by the policy of the state, industries have been favored in making use of its watercourses and communities have thereby grown up in connection with these industries; that the depletion of water from streams might vitally affect the welfare not only of these industries, but of the communities they support; that the plan represented in this resolution represents a long step forward in the conservation of our natural resources; and that it is constructive legislation, both constitutional and progressive."

In a case involving the constitutionality of the Connecticut Flowage Act (Chap. 65, Gen. Statutes of Conn.) Judge McCurdy (*Olmstead* v. *Camp*, 33 Conn. 532, decided in 1866) said: "It would be difficult to conceive a greater public benefit than garnering up the waste waters of innumerable streams and rivers and ponds and lakes, and compelling them to drive mills, and thereby build up cities and villages, and extend the business, the wealth, the population and prosperity of the state."

In the records of the Supreme Court of the United States, Monday, April 17, 1916, are found Nos. 863, 864, 865, *Manchester et al, plaintiffs in error*, v. *The Board of Water Commissioners of the City of Hartford.* In error to the Supreme Court of State of Connecticut. *Per Curiam:* — Judgment affirmed with costs upon authority of *Fall Brook Irrigation District* v. *Bradley* (164 U. S. 112, 160), *Clark* v. *Nash* (198 U. S. 361, 367–

369), *Hairston* v. *Danville & Western Ry.* (208 U. S. 598), *Union Line Co.* v. *Chicago & N. W. Ry.* (233 U. S. 211, 218–219), *O'Neil* v. *Learner* (239 U. S. 244, 253), *Mount Vernon Cotton Duck Co.* v. *Alabama Power Co.* (240 U. S. 30, 32).

In the last case the Court declared (Mr. Justice Holmes): "In the organic relations of modern society it may sometimes be hard to draw the line that is supposed to limit the authority of the legislature to exercise or delegate the power of eminent domain. But to gather the streams and rivers from waste and draw from them energy, and so to save mankind from toil that it can be spared, is to supply what, next to intellect, is the very foundation of our achievements and all our welfare. If that purpose is not public we should be at a loss to say what is."

The portion of the act authorizing the construction of this compensating reservoir states in substance: Sec. 4 (Chap. 367 Special Acts and Resolutions of the General Assembly of the State of Connecticut, January Session, 1911), "Said Board of Water Commissioners is hereby further authorized to build on the East Branch of the Farmington River . . . a dam . . . with all necessary spillways, locks, gates, and appliances for regulating the discharge and flow of water . . . and there to construct a reservoir for storing and ponding the waters of said East Branch of the Farmington River at times of excess flow in the Farmington River, with authority to use said water so stored for the purpose of returning to said Farmington River, water in lieu of waters of said Nepaug River and Phelps Brook, diverted from said Farmington River as heretofore provided, and to make and enter into contracts and agreements with any person or corporations affected by such diversion, providing that said water so stored, ponded and returned to said Farmington River from said reservoir in said East Branch of the Farmington River shall be in lieu, in full or in part, of damages resulting to such person or corporation by reason of such diversion and to make any and all such contracts, agreements and conveyances as may be necessary or convenient to provide for the ownership, maintenance, care, and control of said reservoir on said East Branch of the Farmington River; and all contracts heretofore made by said Board of Water Commissioners in connection therewith are hereby ratified and confirmed." For text of original agreement and subsequent modification, see Appendices II and III.

Among other requirements, the original agreement provided that the Board of Water Commissioners should place such a sum of money in the hands of the mill owners' corporation that its income would provide in perpetuity for a caretaker in the employ of the mill owners, to operate the gates at the reservoir as required. This agreement was entered into prior to 1911 but could not be fully in force until after the war, at which time the amount originally thought of would have been far too small to accomplish the purpose. After considerable friendly discussion between representatives of the city and the mill owners, a modification was agreed upon which

left the operation of the gates in the hands of the Water Board under direction of the mill owners, as long as this method worked in a satisfactory way. Up to the present time the working of the agreement has been mutually satisfactory.

The cost of construction of the compensating reservoir was as follows:

Paid for land	$120 785
Paid for legal services	25 558
Total	$146 343
Total land purchased	1 705 acres
Average purchase price per acre, about	$70.80
Total appraised value of land purchased	$80 650
Average appraised value per acre, about	$47.50
Ratio, cost to appraised valuation, about	1:5
Average assessed value per acre, about	$20.00

Of the 30 individual parcels of land purchased, two only were appealed to the courts; one on the basis of insufficient offer appraised at $5 455, court award $10 000, in addition to which the legal costs were $3 800; the second carried through the state courts to the United States Supreme Court on the plea of unconstitutionality in condemning land for compensation purposes. Judgment in favor of city. (Supreme Court of Errors, Conn., March term, 1913, *Manchester et al.* v. *Board of Water Commissioners, City of Hartford*, and Supreme Court of the United States, October term, 1915. Nos. 863, 864, and 865.)

The award in this case was $10 000 as against an appraised value of $6 612. The total legal costs in this case to the city were $7 500 additional, of which $5 000 was the cost of carrying the case to the United States Supreme Court.

Dam and appurtenances, about	$360 000
Land purchased, with legal expense	146 343
Construction of roads, 3 miles	43 672
Construction of concrete arch bridge	23 132
Approach to bridge	10 922
Engineering, inspection, consultation, equipment, etc.	48 680
Total cost	$632 749
Total square miles diverted	31.85
Total fall affected, feet*	175
Cost of compensating reservoir per sq. mile per foot fall	$113.45

Through the much appreciated courtesy of several friends, I am enabled to present the results of some diversion settlements recently made.

The compensating reservoir has now been in service for about five years and has apparently functioned in a very satisfactory manner. At least two of the large power users below have materially increased their

*Since the compensating reservoir was built one of the powers has been increased by 35 ft. Increasing the developed fall by this amount, the cost of the compensating reservoir was about $94 per sq. mile per foot fall.

installations and it seems probable that the end is not yet. Roughly speaking, a compensation storage of 100 million gal. has been provided for each sq. mile of watershed diverted.

Since the beginning of the work in 1913, careful records of rainfall and run-off have been kept and from them is a suggestion of what might be worked out in detail for a somewhat more elaborate compensation plan.

Reference is again made to the Report of the Committee* on Water Power Diversion (p. 10), and particularly to the assumption stated to be the probable consensus of opinion of engineers of "a wheel development at

TABLE 1.

TABLE SHOWING DATA RELATING TO WATER POWER ON THE FARMINGTON RIVER BELOW PROPOSED DIVERSION.

(Total area diverted, 31.85 sq. mi.)

As of 1912.

Power.	Catchment area. sq. mi.	Average fall used. ft.	Total capacity of wheels. Cu. ft. per sec.	Hrs. per day.	Reduced to 24 hours per day.	Capacity of wheels. Cu. ft. per sec. per sq. mi. tributary area.	Reduced to 24 hours per day.	Ratio diverted area, to total watershed above privilege.
								%
Pequanock	586	...	...	...	...	...	...	...
Lower	586	10.5	220	10	92	0.38	0.16	5.4
Upper	586	9.5	408	17	289	0.70	0.29	5.4
Rainbow	582	12.7	695	23±	663	1.19	1.14	5.5
Farmington R. P. Co.	580	23.0	870	24	870	1.50	1.50	5.5
Hartford El. Lt. Co.	572	32.0	1 057	24	1 057	1.85	1.85	5.6
Tariffville Lace Co.	572	8.0	No information but not high.					5.6
Grist Mill	441	4.0	No information but not high.					7.4
Unionville	376	19.0	607	20±	514	1.61	1.37	8.5
Unionville	376	19.0	509	14±	301	1.35	0.80	8.5
Collinsville	356	19.0	913	10h	381†	2.57	1.07†	8.9
Collinsville	356	18.0			undeveloped			8.9
		174.7						

†Based on number of hours that wheels actually work.

the water-power privilege being investigated, corresponding to the yield of the tributary watershed in the *seventh* month arranged in order of dryness." Although aware of the tendency in some quarters to utilize a larger proportion of the flood flows, some recent developments by conservatively run hydraulic power plants lead to the conclusion that development of the flow of the seventh driest month is still the practical limit. Considerably greater developments than this have been made even locally but it is extremely probable that factors other than the balance between cost of installation and value of power produced were largely instrumental in final decision.

The flow of the seventh month (average long term) is that flow which will be equalled or exceeded in the remaining five months or, say, 41.6 per

*JOURNAL N.E.W.W. Assoc., Vol. XXIV, No. 1, March, 1910, p. 1.

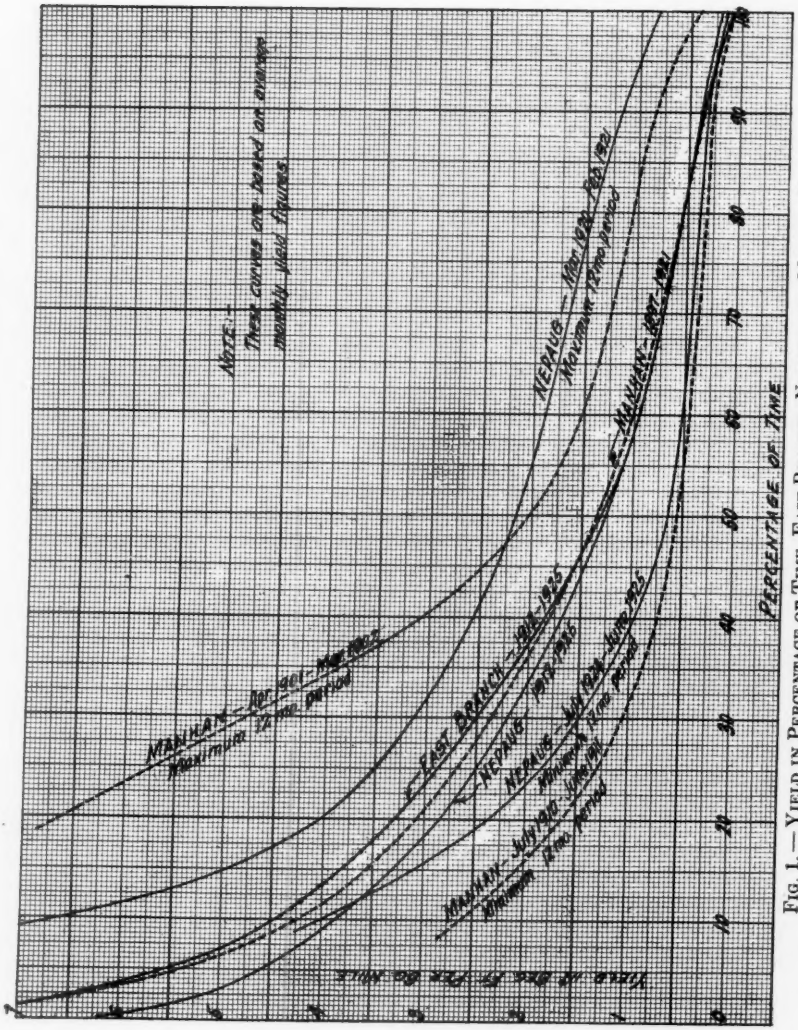
Note:-
These curves are based on average monthly flow figures.
NEPAUG — Mar. 1903 — Feb. 1921
Maximum 12 mo. period
MANHAN — 1897 — 1921
EAST BRANCH — 1914 — 1925
NEPAUG — Mar. 1903 — Feb. 1921
Minimum 12 mo. period
NEPAUG — July 1914 — June 1925
Maximum 12 mo. period
MANHAN — July 1914 — June 1925
Minimum 12 mo. period
PERCENTAGE OF TIME

FIG. 1. — YIELD IN PERCENTAGE OF TIME, EAST BRANCH, NEPAUG AND MANHAN RIVERS.

TABLE 2.

AVERAGE RUN-OFF FOR DRIEST CONSECUTIVE MONTHS FOR YEARS OF RECORD.
PER SQUARE MILE.

Years of Record —	1897–1922.	1908–1922.	1912–1925.	1897–1922.

Number of Consecutive Months.	MANHAN RIVER.		LITTLE RIVER.		NEPAUG RIVER.		NASHUA RIVER.	
	Date.	Cu. ft. per sec.	Date.	Cu. ft. per sec.	Date.	Cu. ft. per sec.	Date.	Cu. ft. per sec.
1	Aug. 1913	0.11	Oct. 1910	0.05	Sept. 1914	0.20	Sept. 1914	0.241
2	July and Aug. 1913	0.14	July and Aug. 1913	0.06	July and Aug. 1913	0.26	July and Aug. 1913	0.263
3	July –Sept. 1913	0.20	Aug. –Oct. 1914	0.09	July –Sept. 1923	0.31	July –Sept. 1913	0.289
4	July –Oct. 1900	0.23	July –Oct. 1914	0.14	Aug. –Nov. 1914	0.41	July –Oct. 1910	0.342
5	July –Nov. 1914	0.28	June –Oct. 1914	0.17	July –Nov. 1914	0.45	July –Nov. 1910	0.365
6	July –Dec. 1914	0.31	June –Nov. 1914	0.28	July –Dec. 1914	0.48	July –Dec. 1910	0.404
7	June –Dec. 1914	0.32	June –Dec. 1914	0.29	July 1924–Jan. 1925	0.49	July 1910–Jan. 1911	0.512
8	July 1910–Feb. 1911	0.40	July 1910–Feb. 1911	0.42	June 1921–Jan. 1922	0.71	July 1910–Feb. 1911	0.560
9	June 1910–Feb. 1911	0.56	July 1910–Mar. 1911	0.57	June 1921–Feb. 1922	0.74	June 1910–Feb. 1911	0.659
10	June 1910–Mar. 1911	0.70	June 1910–Mar. 1911	0.71	May 1921–Feb. 1922	0.87	May 1910–Feb. 1911	0.710
11	July 1910–May 1911	0.80	May 1910–Mar. 1911	0.73	Apr. 1921–Feb. 1922	1.11	Apr. 1910–Feb. 1911	0.801
12	July 1910–June 1911	0.84	Apr. 1910–Mar. 1911	0.88	July 1924–June 1925	1.19	Aug. 1910–July 1911	0.886
15	July 1910–Sept. 1911	0.79	Apr. 1910–June 1911	1.16	July 1924–Sept. 1925	1.04	July 1910–Sept. 1911	0.756
18	July 1910–Dec. 1911	1.07	Apr. 1910–Sept. 1911	1.07	July 1924–Dec. 1925	1.07	May 1910–Oct. 1911	0.835
24	June 1909–May 1911	1.31	Oct. 1909–Sept. 1911	1.41	Jan. 1924–Dec. 1925	1.43	Oct. 1909–Sept. 1911	1.146
30							Mar. 1909–Aug. 1911	1.299
36							Sept. 1908–Aug. 1911	1.250

cent. of the time. The run-off of the Manhan River (Holyoke, Mass., Water Supply, 1897–1921) and of the Nepaug River and East Branch (Hartford, Conn., Water Supply, 1912–1925) drainage areas, 5.7, 31.2, and 61.2 sq. miles, respectively, seems to offer a reasonable criterion, at least for the south-middle New England States. A diagram (Fig. 1) is given herewith, showing the yield of these streams plotted against percentage of time. On this a line has been drawn showing that for the Nepaug River a flow of 1.6 cu. ft. per sec. per sq. mile is equalled or exceeded 41.6 per cent. of the time, or for five months in the average year (so called). For the Manhan River and the East Branch the yield seems to be somewhat greater. This diagram shows also that there have been some years on both the Nepaug and Manhan rivers that have both exceeded and failed to reach this average yield by at least 50 per cent.

Tables* 2 and 3, giving the average run-off for driest consecutive

TABLE 3.

MINIMUM YIELDS FOR CONSECUTIVE WEEKS, APRIL, 1912, TO DECEMBER, 1923, INCLUSIVE.

Actual "Mean Run-off," figures per square mile.

Number of lowest consecutive weeks.	Run-off. Mil. gal. daily.	Run-off. Cu. ft. per sec.	Date.
1	0.085	0.13	Sept. 23–29, 1917
2	0.105	0.16	Sept. 16–29, 1917
3	0.11	0.17	Sept. 13–Oct. 3, 1914 Aug. 3–23, 1913
4	0.11	0.17	Sept. 13–Oct. 10, 1914
5	0.115	0.178	Sept. 6–Oct. 10, 1914
6	0.126	0.195	July 13–Aug. 23, 1913
7	0.129	0.20	July 6–Aug. 23, 1913
8	0.136	0.21	June 29–Aug. 23, 1913
9	0.146	0.227	June 22–Aug. 23, 1913
10	0.156	0.241	July 15–Sept. 22, 1923
11	0.158	0.245	July 8–Sept. 22, 1923
12	0.171	0.265	July 1–Sept. 22, 1923
13	0.181	0.28	June 24–Sept. 22, 1923
14	0.189	0.293	June 17–Sept. 22, 1923
15	0.204	0.316	July 7–Oct. 19, 1912
16	0.202	0.313	June 30–Oct. 19, 1912
17	0.203	0.314	June 17–Oct. 13, 1923
18	0.198	0.306	June 17–Oct. 20, 1923
19	0.226	0.349	June 10–Oct. 20, 1923
20	0.257	0.398	June 2–Oct. 19, 1912
21	0.262	0.404	June 21–Nov. 14, 1914
22	0.266	0.411	June 14–Nov. 14, 1914
23	0.278	0.429	June 7–Nov. 14, 1914
24	0.292	0.451	June 14–Nov. 28, 1914
25	0.295	0.455	June 21–Dec. 12, 1914
26	0.297	0.459	June 14–Dec. 12, 1914

*From JOURNAL N. E. W. W. Assoc., Vol. XXXIX, No. 1, pp. 8 and 9.

months for several streams and minimum yields for consecutive weeks for the Nepaug River, are introduced for the purpose of giving ready reference to some data which may be of value in studies for compensation.

The Nepaug Reservoir (Hartford's Water Supply basin) has a capacity of 7 240 million gal. of water available at its present outlet. The drainage area comprises 31.84 sq. miles, of which 30.5 sq. miles are land and 1.85 sq. miles water surface. From a study of the recorded yields of this basin since 1912 and from the records of the Manhan River prior to that date, it appears that 30 million gal. per day, or about one million gal. per day, or 1.547 cu. ft. per sec. per sq. mile, is the practical limit of this watershed, with due regard to seasons of drought and length of time reservoir will not fill. That is to say, a development to the extent of about 250 million gal. storage per sq. mile, land surface only (actually 237 million gal.), seems to be the conservative limit of the class of stream feeding this reservoir under the given conditions of depth and surface area.

The average monthly yield of the Nepaug River watershed for the years of record (1912–1925), by months, arranged in order of dryness is given below:

Order.	Month.	Run-off.		
		Inches on watershed.	Cu. ft. per sec. per sq. mi.	Average cu. ft. per sec. per sq. mi.
Driest	September	0.64	0.57	
2	August	0.70	0.61	
3	July	0.77	0.67	
4	October	1.29	1.12	1.00
5	June	1.26	1.13	
6	November	1.45	1.30	
7	December	1.86	1.61	
8	February	1.98	1.90	
9	January	2.26	1.96	
10	May	2.70	2.34	2.76
11	April	4.00	3.59	
Wettest	March	4.63	4.00	
	Year	23.54	1.734+	

The arithmetical average discharge of the seven driest months, given above, is about 1 cu. ft. per sec. per sq. mile, or 646 317 gal. For the five remaining months the compensation requirements are 1.61 cu. ft. per sec. per sq. mile. $2.76 - 1.61$ equals 1.15 cu. ft. per sec. for five months, equivalent to 0.480 cu. ft. per sec. for the entire year, under the assumed development to the discharge of the seventh month. This excess or waste, after satisfying power requirements amounting to 310 000 gal. per day per sq. mile, is available for city water supply without damage to power. But as this excess is about one-third of the yield of the Nepaug watershed, it seems that, generally speaking, on a New England watershed when de-

veloped for conservation up to a reasonable limit, if two-thirds of the yield is allocated to power users, one-third may be used for municipal purposes without detriment to riparian owners.

Applied to the Hartford additional water supply development with its yield of 30 million gal. per day, 10 million gal. per day would have been available for city use, which, added to the yield of the sources in use before the new development, would have made a total of 17 million gal. per day, or about the present demand. Construction work on the compensating reservoir was begun in 1915, and under this plan it could have been deferred for 10 years. With the knowledge of conditions and the attitude of the mill owners prior to the passage of the legislation act in 1911 authorizing the work, it is a wild dream of fancy to think that this plan could have been given any consideration whatsoever. It is interesting and perhaps instructive, however, to speculate somewhat on what might have been if foresight could have equalled hindsight, and it is possible now that with the knowledge gained both by mill owners and city authorities, a method of compensation less expensive for the city and more favorable for the mill owners might be arranged, which would be mutually satisfactory. For instance, had it been possible to compensate, as suggested above, from the Nepaug Reservoir and delay building the compensating reservoir, there would have been an annual saving in interest and sinking fund charges for ten years, amounting to about $30 000. This amount, considered as an annuity at 4 per cent., would have resulted in the capital sum of $360 000 or more than half the cost of the compensating works.

As intimated above, however, the fly in this ointment is the fact that in 1911 this would probably have been an impossible solution. Therefore, on looking backward, it is proper and pleasing to say that the plans worked out 15 years ago seem now to have been best.

Now to proceed further with this thought of compensation after the limit of what might be called free water has been reached, i.e., when in order to supply city demands it is necessary to encroach upon power requirements. Two methods of handling the matter are available, not considering the ordinary one of purchasing outright the power lost by diversion. One of these is to build a reservoir for compensation purposes, as in Hartford; the other, to pay annually to the power owners the value of the diverted water in terms of purchased power until such time as the entire yield of the watershed has been appropriated, and then settle in cash or, if possible, by compensating water from another reservoir to be constructed for the purpose.

These plans are subject, of course, to mutual agreement between city authorities and power users, and my own experience after dealing with some of the shrewdest manufacturers and corporation lawyers in the country is that a common ground can be found, to the mutual satisfaction of all parties, provided all are honestly and fairly inclined.

The latest agreement for allocation of water from interstate drainage

areas is the so-called "Tri-State Compact" as to the water resources of the Delaware River, between the Commonwealth of Pennsylvania, the State of New Jersey, and the State of New York. While this agreement does not deal with compensation it is interesting and instructive to note the advance in civilization and how sovereign states now handle such vitally important matters instead of going to war.

The best and latest advance along this line of compromise and compensation-in-kind is the plan proposed by Mr. X. H. Goodnough, Mem. Am. Soc. C. E., Chief Engineer of the Massachusetts State Department of Health, and an honored member of this Association, in the matter of water supply for the Boston Metropolitan District, taken from the Ware and Swift rivers in central Massachusetts.

Briefly, and quoting from the report of the Joint Board, dated January, 1922* p. 17, "We have, therefore, endeavored to work out a plan for utilizing the Ware River water in such a way as to interfere as little as possible with the flow of the lower river. This can be done by diverting Ware River water to Wachusett Reservoir and to Pine Hill Reservoir of the Worcester supply at times when the Ware River flow is high, — say, above 1.2 cu. ft. per sec., or 800 000 gal. per day for each sq. mile, — and at those times only. This will not interfere with the flow of the stream during those periods of the year when it is naturally low." In the act as passed in 1926 (Chap. 375) providing for this additional water supply, Mr. Goodnough's plans were substantially approved and carried out. Provision was made (Sect. 1) for diverting flood waters of the Ware River, but with no diversion between May 31 and December 1 in any year unless approved by the State Department of Health, and in Section 4, flood waters were defined for the purpose of this act to be "in excess of a flow of eighty-five million gal. per day, meaning thereby that on any day when the natural flow of said river is less than eighty-five million gallons no water shall be diverted." Eighty-five million gal. per day from above the point of diversion is approximately equivalent to a discharge of 1.2 cu. ft. per sec. per sq. mile.

The Massachusetts Legislature has in several cases recognized the need of riparian owners below points of diversion, in addition to damage that could be compensated for in money. In 1872 the city of Boston, in its development of the Sudbury River, was required to allow an amount of water to run in the stream, equivalent to 20 000 gal., or about 0.031 cu. ft. per sec. per sq. mile diverted; in the taking of the Nashua River in 1895, the allowance was 29 000 gal., or 0.045 cu. ft. per sec. per sq. mile, and in the case of diversions of the Ipswich River, it was provided that after 1913 water could be diverted only when the flow of the river exceeded about 0.35 cu. ft. per sec. per sq. mile of tributary drainage area.

It is, of course, impossible to make any general rule as to the limit above which water may be diverted without damage to riparian ownership because of conditions peculiar to each watershed or stream use.

*Mass. House Doc. No. 1550, January, 1926.

Summary.

Upon consideration of the several major diversions settlements mentioned in this paper, it appears:

1. That Hartford, Conn., in 1911 blazed the path for compensation-in-kind in lieu of money payment, through court action.

2. That Mr. X. H. Goodnough in 1922 established the principle of utilizing wasted flood flows for diversion purposes, and his recommendation was approved by the Massachusetts Legislature in 1926.

3. That Providence, R. I., in 1925 and prior, instituted the method of daily allocation of water from its water-supply reservoir to mills below, as part payment for diversion damages; this allocation decreasing annually to accommodate increasing needs of the city, this plan being suggested by the late Mr. F. P. Stearns, Cons. Engr.

These three factors combined constitute a basic principle on which to construct a rational method for settlement of water diversion controversies in lieu of payments in cash for riparian damage.

In presenting the following data on water diversion settlements (Appendix I), especial mention is made of the courtesy of Prof. H. K. Barrows, in allowing the publication of two tables from his forthcoming book on Water Power Engineering. In his letter sending this data Professor Barrows says "In general I find that the amount paid on the basis per horse power of whole installation is a more useful index than that per square mile per foot fall. The latter, as you are probably aware, is hardly common — at least in the Courts." In my own observation I quite agree with Professor Barrows as to the best unit for study of damage to going installations, but presume that the unit of the Committee (1910) report was a more convenient form for comparison of widely scattered plants with data of detail none too complete.

Appendix I. Data on Water Diversion Settlements.

From letter from Mr. Arthur H. Pratt, Chief Engineer, North Jersey District Water Commissioners, quotation is made as follows:

The right of the Weidman Silk Dyeing Company and the National Silk Dyeing Company of Paterson to draw water from the Passaic River at Paterson as against the City of Newark, which diverts the complete development of the Pequannock River, a tributary of the Passaic, is as follows:

> "The right to take and divert continuously such of the waters of the Pequannock River above the Macopin Intake necessary for the public water supply of the city of Newark and such territory as is now or may in the future be supplied from said municipal plant."

These people did not use the river for power. The takings by Newark and Jersey City were adjudged to so seriously affect the low flow of the river that the plants could not get water for their processes during times of low flow. The East Jersey Water Company paid for Jersey City under the terms of their old Boonton contract.

The testimony shows that Mr. John H. Cook and Mr. Morris R. Sherrerd apportioned the amount of the effect of the taking by Newark as 7.1 million gal. per day on the low flow at Weidman's, about half as much at the National Silk Dyeing and the taking by Jersey City at 13.6 million gal. per day. The area of the Passaic River at Weidman's is about 800 sq. miles.

The Newark judgments were as follows:

Nov. 27, 1923	— Weidman Silk Dyeing Co.	$102 187.32
May 19, 1925	— Weidman Silk Dyeing Co.	9 800.00
1913	— Weidman Silk Dyeing Co.	9 590.17
Nov. 27, 1923	— National Silk Dyeing Co.	42 422.60
May 1925	— National Silk Dyeing Co.	14 000.00
1913	— August Simon, predecessor to National Silk Dyeing Co.	2 583.00

The following table was supplied by Mr. Charles T. Main, designer of Industrial Plants, Boston, Mass.:

	Watershed Takings.		Developed Privileges.		
Location.	Total.	Watershed, sq. miles. diverted.	Available fall. ft.	Price (excl. interest) per sq. mi. per ft. fall.	
Syracuse Suburban Water Co.	46.3	10	15	$49.00	Reported by Leonard Metcalf.
	50.1	10	9	11.00	Letter 1/24/25.
	63.7	10	8	44.00	Takings in 1908 by agreement.
	70.6	10	13.5	11.00	
	70.6	10	14.0		
	70.6	10	15.	51.00	
	72.2	10	12.5		
	72.2	10	12.		
	72.2	10	17.	88.00	
	72.2	10	15.	78.00	
	73.9	10	17.		
	72.8	10	18.	125.00	Includes right of way.
	72.8	10	16.	53.00	
	80.8	10	17.	None	
	80.8	10	17.	50.00	
Weighted average				$53.00	
City of Baltimore takes Warren Mfg. Co., whole development	275	275	14.4	$18.90	C.T.M. with water powers and mills taken by agreement 1921.
City of Baltimore takes Phoenix plant, 1921	180	180	11.2	19.40	
So. Manchester, Conn., Water Co. *v.* Angus Park Mfg. Co. plant, 1922	9	5.1	20	193.00	By agreement approximately only—guaranteed min. flow let down also.

The costs in the case, extending from 1913 to 1922, charged against Newark, were $20 008.73.

Water actually taken: Weidman, about 6 million gal. per day, National Silk Dyeing, about 3 million gal. per day. Now supplied by arrangement with Passaic Consolidated Water Company. Damage was awarded on basis of excess cost of getting water from Dyers Pipe Line over previous cost of pumping from river.

From data furnished by Mr. Stephen Taylor, Superintendent Water Department, New Bedford, Mass., July 12, 1926:

1899, city of New Bedford settled claim of State Mills Corporation, of Middleboro, on account of taking of Little and Great Quittacas Ponds for water supply. 12.8 sq. miles of a total of 60.1 sq. miles, total head at mill, 12 ft. Case settled out of court for $4 500, equivalent to about $29.30 per sq. mile per ft. fall.

1906, city of New Bedford settled another claim on this same river with the town of Middleboro, for diversion of the same 12.8 sq. miles from a total of 59.6 sq. miles with a head of 10 ft. Claim settled for $6 800, or about $53.10 per foot fall per sq. mile.

SUMMARY OF AWARDS IN VARIOUS CASES OF DIVERSION OF FARMINGTON RIVER AND TRIBUTARIES, CONN., DEVELOPED PRIVILEGES. (AWARDS GENERALLY BY AGREEMENT.)

Approximate date and name.	Total area, sq. mi.	Area diverted, sq. mi.	Gross fall, ft.	Award.	Award, per sq. mi. per ft. fall.
Bristol Water Co. cases:					
1910 Bristol Mfg.	22.8	6.9	18	$3 000	$24.20
" Hills Novelty Co. and George W. Eaton	46.4	6.9	14	5 100	52.80
1910 Clark Castor Co.	46.8	6.9	5	1 500	43.50
1911 C. J. Root Co.	19.5	6.9	3.75	501	19.36
" Penfield Saw Works	33.	6.9	6	802	19.36
" New Departure Mfg. Co.	33.	6.9	10	1 336	19.36
" Bristol Brass Co.	33.	6.9	22	2 939	19.36
" Joseph Masseck	28.	6.9	11.3	1 510	19.36
" Sessions Clock Co.	47.	6.9	20	2 672	19.36
" Estate C. E. Andrews	...	...	...	1 250	...
1913 Tariffville Lace Mfg. Co.	586.	6.5	9	2 900	49.50
New Britain Cases: (Whigville Diversion 1909–1912.)					
Eaton & Hills	46.4	3.94	14	6 500	118.00
Clark Castor Co.	46.8	3.94	5	2 400	122.20
Sessions Clock Co.	47.	6.9	20	11 500	146.00
Bristol Brass Co.	33.	6.9	22	9 850	113.10
W. H. Carpenter	...	3.94	...	2 100	...
A. S. Pong	...	3.94	6	2 250	95.40
Tariffville Lace Mfg. Co.	555.	3.94	9	2 000	56.40

From Metcalf & Eddy,* through courtesy of Mr. John P. Wentworth:

Several water companies controlled by the New Jersey General Security Co. purchased the right from the Society for Establishing Useful Manufactures and the Dundee Water Power and Land Co. to divert

*Consulting Engineers, 14 Beacon St., Boston, Mass.

75 million gal. per day from the Passaic River. The Society owned the water rights at Great Falls, at which point the available fall in the river is 69 ft. The Dundee Water Power and Land Co. owned the water-power rights at Dundee Dam, at which point the fall is 21 ft., making a total fall of 90 ft. at the two dams. The average drainage area at Great Falls and Dundee Dam is 618 sq. miles. The price paid was $1 120 000 (about $200 per sq. mile per ft. of fall — C.M.S.).

Connecticut: Tariffville, Hartford County, Dec. 1913: Tariffville Lace Mfg. Co. *v.* Bristol Water Co. developed privilege on Farmington River. Authority, Charles W. Sherman. By agreement.

Watershed diverted 6.5 sq. miles out of 586 sq. miles. Fall 9 ft., wheel installation consists of 3 old American wheels of 90 h. p. and 1 nearly new Trump of 140 h.p. Plant now used for manufacturing chemically pure oxygen gas. No steam power. Power used 24 hours per day, 365 days per year. Pondage in river approximately 4 miles long and averaging 125 ft. wide; from 1 to 2 ft. in depth can be utilized. Paid $49.50 per sq. mile per ft. fall.

From Mr. Frank E. Winsor, Chief Engineer, Water Supply Board, Providence, R. I.

Briefly, our settlements for water diversion have been as follows:

Hope Company: Two cotton mills. Claim mainly for water power.

Tributary drainage area: for upper mill 98.2 sq. miles; for lower mill 104.4 sq. miles.

Area diverted: 92.8 sq. miles.

Available storage above mill ponds owned jointly by four companies: 2 910 million gal.

Amount paid as of September 20, 1922: $395 447.80, or about $108 per sq. mile per foot fall.

Developed head total 39.4 ft.

B. B. & R. Knight, Inc.: Four mills and one mill privilege upon which mill had been destroyed by fire. Claim was for loss of power except in case of mill having tributary drainage area of 196.3 sq. miles where a large claim was made on account of pollution of stream resulting from diversion.

Tributary drainage areas: 100.4 sq. miles; 104.4 sq. miles; 180.1 sq. miles; 196.3 sq. miles for the mill privilege upon which mill had been destroyed by fire, 101.8 sq. miles.

Area diverted: 92.8 sq. miles.

Available storage from mill ponds owned jointly by four companies: Two mills having drainage areas of about 100 sq. miles, 2 910 million gal.; two mills having larger drainage areas, 5 910 million gal.

Developed head, not including site where there is no mill, totals 54.3 ft.

Amount paid as of September 20, 1922: $783 035.90, or about $155 per sq. mile per foot fall.

Interlaken Mills: Two cotton mills, also a finishing plant and dye works.

Claim was that diversion of water destroyed value of water powers, and also for pollution, the latter claim being particularly heavy.

Tributary drainage areas: 102.2 sq. miles and 102.9 sq. miles.

Area diverted: 92.8 sq. miles.

Available storage above mill ponds owned jointly by four companies: 2 910 million gal.

Developed head total, 36.5 ft.

VALUE OF DEVELOPED WATER PRIVILEGES.

H. K. Barrows.

Location.		Drainage area. Sq. Mi.		Head.	Wheel. (or estimated) H.P.		Amount paid.			
River.	State.	Total.	Taken.	Ft.	Total.	Taken.	Per h.p.	Per sq. mi. per ft. fall.	Remarks.	Date.
Great Brook	Conn.	6.44	6.44	10	9.3	9.3	$750.00	$108.60	Small saw mill included in agreement includes land for dam site.	1901
Briggs Brook	Conn.	2	1.64	51	14.8	12.2	655.00	95.60	Also used as ice privilege.	1897
French	Conn.	94	94	1.5	20.6	20.6	365.00	53.20	Cotton Mill, 10-hr. power.	1870
West Brook, Naugatuck	Conn.	20	18	7	20.4	18.4	109.00	15.90	Grist Mill	..
West Brook, Naugatuck	Conn.	21	18	12	36.6	31.5	95.00	13.90	Saw mill.	..
West Brook, Naugatuck	Conn.	23	18	18	43.5	34	206.00	29.90	Cutlery factory.	..
West Brook, Naugatuck	Conn.	23.2	18	7	23.6	18.3	65.00	9.52	Saw mill.	..
Kettle Brook	Mass.	5.02	3.86	22.35	45	34.6	885.00		Woolen mill.	1895
Kettle Brook	Mass.	5.17	3.86	10.87	29	21.6	467.00	242.80	Satinet Mill.	..
Beaver Brook	Mass.	2.68	2.6	20.5	8	8	125.00	18.80	Silk Print Works. 10-hr. power.	1900
Wachusett Reservoir	Mass.	{113.4	113.4	15.5	196	196	317.00	35.20	Yarn mill { 58 hrs. per week power.	
		{118.23	118.23	28	535	535	540.00	87.30	Cloth mill {	1897
Sudbury	Mass.	100.00	75.2	26	378	284	460.00	67.20		1878
East Meadow	Mass.	7.75	7.75	9	10	10	300.00	43.00	10-hr. power.	1896
East Meadow	Mass.	7.5	7.5	8	8.7	8.7	344.00	50.00	10-hr. power.	1899
South Brook, Nashua	Mass.	128.8	118.2	8	150	138	254.00	37.00	Cotton mill.	1897
Sudbury	Mass.	2.6	2.6	18	6.8	6.8	280.00	40.60	Includes land.	1895
Nemasket	Mass.	59	48.1	10	150	122	61.00	12.70	Electric lighting plant, 150 h.p. steam.	1909
South Brook, Nashua	Mass.	94.8	94.8	27	617	617	146.00	35.15	Part of 10.9 sq. mi. additional area taken.	1896
Quinepoxet	Mass.	{53.8	53.8						White Cotton mill.	
	Mass.	{54.2	54.2	39.7	382	382	136.00	24.30	Cotton mills. Two developments. 10-hr. power.	1896
Branch of Stony Brook	Mass.	4.14	4.14	8	4.8	4.8	350.00	51.35		
Nashua	Mass.	98.3	98.3	11	128	128	172.00	20.70	Cloth mill, 10-hr. power.	1896
Nashua	Mass.	98.3	98.3	11	125	125	176.00	20.70	Grist mill, intermittent power.	1903
Nashua	Mass.	98.9	98.9	18.4	178	178	300.00	29.10	Corset, jeans, quilts, etc.	1896
Little Squam Lake	N. H.	56.75	56.75	29	240	240	48.00	6.08	Grist mill and repair shop. 24-hr. power.	1888
Newfound Lake and River	N. H.	91	91	46	610	610	24.00	3.58	Saw mill and pulp mill. 24-hr. power.	1884
Lake Winnepesaukee	N. H.	{366	366	12					Cotton and woolen mills. 12 and 24-hr.	
		{428	428	16	1 640	1 640	52.00	6.75	power. Includes land and buildings.	1889
Smith's and Crooked Ponds	N. H.	24	24	18	63	63	95.00	13.87		1889
Penobscot	Me.	5 100	....	19	2 860	....	157.00	4.65	Sale.	1925
Spicket	N. H.	20	.. .	16	46	....	260.00	3.75	Sale.	1923
Ipswich	Mass.	127	43	6	66	6.5	500.00	4.20	Agreement.	1920
Otter Creek	Vt.	855	....	35	1 500	....	133.00	6 50	Sale.	1912
Saranac	N. Y.	607	....	9	100	....	150.00	2.76	Sale.	..

VALUE OF UNDEVELOPED, ABANDONED OR UNUSED WATER POWER PRIVILEGES.

H. K. Barrows.

Location.		Drainage Area. Sq. Mi.		Head.	Wheel. (or estimated) H.P.		Amount paid.			
River.	State.	Total.	Taken.	Ft.	Total.	Taken.	Per h.p.	Per sq. mi. per ft. fall.	Remarks.	Date
Ten Mile River	Conn.	6.3	1.6	16	14.6	3.7	$40.50	$5.86	Cider and saw mill.	1908
Great Brook	Conn.	16.4	6.44	9.5	22.7	8.9	135.00	19.60		1901
Great Brook	Conn.	16.4	6.44	9.1	21.7	8.5	177.00	25.60	Includes mill site.	1901
Great Brook	Conn.	14.2	6.44	11	22.7	10.3	58.00	8.50		1908
Whetstone Brook	Conn.	14.75	0.43	12	25.7	0.75	88.00	12.80	Abandoned and dismantled privilege.	1888
Kennebec (tributary)	Me.	200	200	48	(980)	(980)	23.80	2.50		1901
Munn's Brook	Mass.	21	6.4	10	30.5	9.3	53.80	6.98	Power not used for years, mill burned down.	1900
Quackenkill Brook	N. Y.	91.3	17.5	55.1	730	140	42.90	6.23	Storage contracted by privilege below.	..
Quackenkill Brook	N. Y.	91.3	17.5	10.6	140	27	37.00	5.40	Storage contracted by privilege below.	..
Quackenkill Brook	N. Y.	18.1	17.5	74	194	188	7.20	1.04	Storage contracted, abandoned privilege.	..
Taughannock Brook	N. Y.	67	67	543	5 300	5 300	15.10	2.21		..
Fish Creek	N. Y.	13.5	135	273	2 500	2 500	2.90	0.20		1903
Tomhannock Creek	N. Y.	75	67	150	1 640	1 465	15.00	2.19	Privilege abandoned and plant destroyed	..
Tomhannock Creek	N. Y.	78	67	40	455	390	41.00	5.97		..
Tomhannock Creek	N. Y.	80	67	8	93	78	15.40	2.24	Formerly developed, plant destroyed.	..
Kennebec	Me	1 300	....	350	68 000	....	10.00	1.43	Sale.	1913
Kennebec	Me.	3 950	....	32	12 000	....	33.00	3.95	Sale.	1917
Androscoggin	Me.	2 800	....	30	8 400	....	34.00	3.40	Sale.	1915
Androscoggin	Me.	2 800	....	40	12 000	....	30.00	3.10	Sale.	1915
Mendon Str.	Vt.	10	10	43	120	120	22.00	5.80	Settlement.	1916
Spicket	N. H.	23	....	12	40	....	300.00	43.50	Sale — abandoned privilege.	1921
Spicket	N. H.	22	....	12	40	....	75.00	11.30	Sale — abandoned privilege.	1921
Ipswich	Mass.	43	....	10	70	30	500.00	35.00	Settlement — unused privilege.	1920
Penobscot	Me.	436	....	40	3 000	....	25.00	4.30	Cost of privilege before development.	1903
Penobscot	Me.	443	....	51	5 000	....	46.00	10.20	Cost of privilege before development.	1913
Penobscot	Me.	569.	....	28	2 400	....	104.00	15.70	Cost of privilege before development.	1907

Amount paid as of September 20, 1922 — $581 147.55, or about $171 per sq. mile per foot fall.

All of the above settlements were made without litigation.

Clyde Print Works: A plant devoted solely to bleaching, printing and dyeing was settled as a result of a suit.

Claim was that diversion destroyed value of water power, left insufficient water for process purposes and necessitated filtration on account of diversion.

Tributary drainage area: 106.0 sq. miles.

Area diverted: 92.8 sq. miles.

Available storage above mill ponds owned jointly by four companies: 2 910 million gal.

Developed head totals 9.3 ft.

Amount paid as of May 19, 1920: $265 000, or about $307 per sq. mile per foot fall.

The claims that were settled by negotiations involved making a contract with the three companies whereby the city is required to draw daily from the Scituate Dam for use of the mills a certain amount of water, decreasing yearly until 1955, this quantity being based on the assumption of the difference between consumption by the city and the 70 million gal. per day which under the law the city was previously required to draw from the reservoir.

The following information has been received from the Board of Water Supply of the city of New York through the courtesy of Mr. John M. McManus, Chief of Bureau of Claims.

On the Esopus Creek below the Ashokan Reservoir the following water powers were awarded damages:

E. I. du Pont de Nemours Power Co., at Brown's Station:

Developed.

Distance below city's Olive Bridge Dam....	1.4 miles
Original drainage area.....	264 sq. miles
Drainage area diverted by city.....	249 sq. miles
Drainage area unaffected by city of New York	15 sq. miles

Head — 27 feet.

Award as of year 1914 — $76 092.

Award per sq. mile diverted per foot of fall — $11.32.

Remarks: Upon the property was a wood flour pulp mill with 1 665 h.p. installed. There were 13 wheels, ten for grinders, one for blowers, one for cutters, and one for electric generator, — all supplied by a 14-ft. steel penstock. No auxiliary power. Mill building of skeleton steel construction covered with corrugated iron. Besides the mill on the property were a press house, storage house, dwellings, and barns. Capacity of pond 1 988 500 cu. ft. Buildings removed and property sold after case was tried.

Crane, Kerr & Gallagher Grist Mill, at Legg's Mills:

Developed.

Distance below city's Olive Bridge Dam...	25.6 miles
Original drainage area.....	370 sq. miles
Drainage area diverted by city of New York	249 sq. miles
Drainage area unaffected by New York City	121 sq. miles

but city of Kingston takes some water from 41 sq. miles of this

Head — less than 7 feet.

Award as of year 1915 — $6 500.

Remarks: Grist mill operated by a Reynolds 30-in. turbine. No auxiliary power. A saw mill immediately below has surplus water-power rights from same flume. An award was made for these rights but was not separated from a riparian rights award for 2 056 ft. of creek frontage on which was located a large bungalow colony. The award for surplus water power rights, plus riparian rights, was $5 000.

James H. Sands, at Glenerie Falls:

Undeveloped.
Distance below city's Olive Bridge Dam.. 27.8 miles
Original drainage area..... 416 sq. miles
Drainage area diverted by city of New York 249 sq. miles
Drainage area unaffected by New York City but partly affected by city of Kingston and village of Saugerties.... 167 sq. miles
Kingston has rights to 8 sq. miles above Ashokan Reservoir and 33 sq. miles below. Saugerties has rights to 17 sq. miles below Ashokan Reservoir but above property in question. Only small portions of these watersheds used by Kingston and Saugerties (249+8+33+17+109=416 sq. miles).
Head — 65 ft.
Award as of year 1915 — $18 500.

Remarks: Property consisted of 128 acres of land lying on both sides of Esopus Creek for six-tenths of a mile. Three falls with extended rapids between. The upper falls were developed and abandoned, as were the lower; but the middle falls were never developed. Sands acquired total fall by three purchases. Lower falls had a white lead plant consisting of mills and a village with dwellings, church, school, and stores. Plant ceased manufacturing white lead in 1896 and property let go to ruin. Some work started on a new development at time of city's coming, but nothing has been done since.

Water Powers at Saugerties:

Developed.
Distance below city's Olive Bridge Dam . 32.8 miles
Original drainage area..... 424 sq. miles.
Drainage area diverted by city of New York 249 sq. miles
Drainage area unaffected by New York City but partly affected by city of Kingston and village of Saugerties.... 175 sq. miles
Head — 46.5 ft.
Awards as of year 1915 — Martin Cantine Company, Diamond Mills Paper Company and Sheffield Estate — $150 000.
Award per sq. mile diverted per ft. of fall — $12.95.

Remarks: Rights:

Diamond Mills Paper Co. — first right to use of 1.26 c.f.s. for process purposes.
Martin Cantine Co. — perpetual second right to 137.5 c.f.s. under a 46.5 ft. head.
Diamond Mills Paper Co. — perpetual third right to 173.7 c.f.s. under a 46.5 ft. head.
Sheffield Estate — perpetual fourth right to 136.4 c.f.s. under a 14-ft. head.

Diamond Mills Paper Co. — perpetual fifth right to 136.4 c.f.s. under a 32.5 ft. head.
Diamond Mills Paper Co. — perpetual sixth right to water, in excess of other rights, that the canal will carry, under a 46.5 ft. head.
Cantine received $53 000, Diamond Mills $90 000, Sheffield $7 000.
Area pond, 105 acres — can be drawn down 5 ft.
Mills have auxiliary steam power.

The Esopus Creek rises at the foot of Slide Mountain in the Catskills and flows in a northeasterly and then a southeasterly direction over a Devonic formation of alternate layers of bluestone and shale. As it emerges from the mountains it is deflected northeasterly by the underlying Onondaga limestone formation and eventually flows into the Hudson at Saugerties, 63 miles by creek from its source. The topography is rugged and steep, the rock lies close to the surface and there is no lake storage, so the stream is extremely flashy. Between 1906 and 1913 flows have varied from 18 c.f.s. to 28 100 c.f.s. at Esopus Weir (239 sq. miles drainage area), and since 1913 from 8 c.f.s. to 32 816 c.f.s. at Coldbrook (192 sq. miles drainage area). The rainfall averages about 48 in. per year and the run-off is about two-thirds the rainfall.

Appendix II.

This Agreement made this 1st day of May, 1911, by and between the Board of Water Commissioners of the city of Hartford, party of the first part, and parties of the second part, Witnesseth:

Whereas the party of the first part has petitioned the General Assembly of the State for authority to acquire additional water supply for the City of Hartford and the exercise of the powers sought would involve the diversion from the Farmington River of the waters of the Nepaug River and Phelps Brook, so-called, entering the Farmington River in the neighborhood of Collinsville, and it is claimed that such diversion would impair the water powers owned by the parties of the second part respectively; and

Whereas for the purposes herein set forth the party of the first part proposes to obtain from the General Assembly authority to construct a reservoir to store the waters of the East Branch of the Farmington River;

Now, therefore, the parties hereto, each in consideration of the other's undertakings, hereby agree as follows:

The party of the first part agrees with the parties of the second part and each of them, in the event that the General Assembly shall at its present session grant to the party of the first part authority to take the waters of Nepaug River and Phelps Brook, then:

First: That the party of the first part shall, before any waters thereof shall be diverted from the Farmington River, and for the sole purpose of securing a more uniform flow of said River, acquire the land for and construct and complete in a thorough and workmanlike manner, ready for

operation, a reservoir upon the East Branch of Farmington River, in the towns of New Hartford and Barkhamsted, with a capacity of Three Thousand Million Gallons should it be built at the lower site, so-called, near the iron bridge, where the catchment area is at least sixty square miles; and in case it is found that a dam can be better built at a site at some point above where the drainage area is not less than fifty square miles that the capacity of said reservoir shall be Three Thousand One Hundred and Fifty Million Gallons.

Second: That the party of the first part shall, on or before the completion of the proposed reservoir, execute a contract with a corporation to be organized by the parties of the second part for the purposes hereof, which contract shall contain the following undertakings:

1. The party of the first part shall agree to maintain and keep in repair said reservoir, its structures and appurtenances, including the gates thereof, in such manner as will insure the preservation of said reservoir, its structures and appurtenances, and the maintenance of the gates in suitable condition for proper control at all times of the waters thereof.

2. The party of the first part shall agree to pay all taxes assessed upon said reservoir and its appurtenances when due, and that it, the party of the first part, will not sell or otherwise alien said reservoir or any flowage or other rights appurtenant thereto, without the consent of the other party to such contract.

3. The party of the first part shall grant to the other party to said contract permission at all times, so long as the waters ponded by such reservoir may be of any value to the parties hereto of the second part, their successors or assigns, or any of them, for manufacturing or power purposes, to control the flow of the waters from said reservoir, and to that end to regulate the gates thereof, in so far as such control shall not interfere with the safety and integrity of said reservoir, its structures and appurtenances.

4. The parties will agree that the party of the first part shall be and remain the owner of said reservoir and that the same shall continue to be the property of the party of the first part, notwithstanding the provisions of such contract, and that the party of the first part shall be liable for all loss, cost and damage resulting to the other party to such contract or to any person or persons, corporation or corporations whatsoever, for any failure of said reservoir, its structures or appurtenances, to safely hold and distribute such waters as may fall, flow and accumulate therein; and that the party of the first part shall indemnify and save harmless the other party to such contract from and against any loss, cost or expense incurred by reason of any claim, demand, suit at law or equity, or any judgment therein in favor of any riparian owner or owners upon the Farmington River or the East Branch thereof below the proposed reservoir by reason of the construction or maintenance of said reservoir or the ponding of the waters therein.

Third: That the party of the first part shall on or before the com-

pletion of the proposed reservoir pay to the parties of the second part or the corporation to be organized by them as aforesaid a sum of money which, invested at four per cent., shall produce a sufficient income to enable the parties of the second part to operate said reservoir under the permission hereinbefore described, including the cost of organization and maintaining such a corporation (not to include officers' salaries, however) and of installing and operating such weirs for water measurement as may be necessary or convenient; which sum, if not agreed to by the parties hereto, shall be determined by three arbitrators, one to be selected by the party of the first part, one by the parties of the second part, and the third to be selected by the two arbitrators thus appointed.

And it being also agreed and understood by and between the parties hereto that the parties of the second part who are owners of water power are to receive shares of the capital stock of said corporation in a proportion estimated upon the basis of their interest as agreed upon between them, said parties of the second part do hereby agree, in the event that all the owners of water power affected by said diversion of Phelps Brook and Nepaug River do not enter into this agreement and become stockholders in said corporation upon its organization, that they will cause to be held in the Treasury of said corporation or in the hands of a trustee, to be appointed for that purpose, until one year after the completion of said reservoir, such shares of stock in said corporation as such owners as shall not enter into this agreement would have been entitled to on such basis if they had become parties to this agreement, hereby further agreeing to cause said shares to be transferred to said respective parties at any time up to a year from and after the completion of said reservoir on request of the party of the first part, provided that if said party of the first part makes no such request within the time aforesaid, then said shares of stock shall become the absolute property of said corporation.

Fourth: The party of the first part further agrees that it will not take any of the waters of the East Branch of the Farmington River or of its watershed otherwise than for the purposes of said reservoir and that it will not in any manner divert such waters from the Farmington River.

The parties of the second part in consideration of the agreements thereinbefore contained on the part of the party of the first part severally agree to and with said party of the first part that they will not oppose the granting by the General Assembly of authority to the party of the first part to take the water of Nepaug River and Phelps Brook for an additional water supply for the city of Hartford, and further severally agree that upon completion of the reservoir as aforesaid, and the execution of the contract as aforesaid, they, the parties of the second part, will severally, for themselves, their successors, executors, administrators, heirs and assigns, covenant and agree with the party of the first part that the additional waters which shall be secured to their respective uses by reason of the proposed reservoir upon the East Branch of the Farmington River shall be treated as compensation

on account of the diversion of any waters taken by the party of the first part from the Nepaug River and Phelps Brook or their tributaries, and that in determining damages, if any, to said several parties of the second part for diversion of the waters so taken, the benefit to them respectively of any increase in the available flow of the waters of Farmington River due to such reservoir shall be treated as an offset *pro tanto* to the damage due to such diversion.

IN WITNESS WHEREOF the parties hereto have set their hands on the day and year first above written.

APPENDIX III.

THIS AGREEMENT made this 15 day of October, 1925, by and between the BOARD OF WATER COMMISSIONERS OF THE CITY OF HARTFORD, hereinafter called the Board of Water Commissioners, party of the first part, and hereinafter called the riparian owners, and THE RIPARIAN COMPANY, a corporation organized under the general law of said State, hereinafter called THE RIPARIAN COMPANY, parties of the second part, WITNESSETH:

WHEREAS the parties hereto, excepting the Riparian Company, entered into an agreement of date May 1, 1911, relating to the construction, ownership and operation of the so-called Compensating Reservoir located on the east branch of the Farmington River in the Towns of New Hartford and Barkhamsted, a copy of which agreement is hereto attached for reference; and

WHEREAS the party of the first part pursuant to its undertakings in the paragraph of said agreement marked "First" did acquire the land for and construct and complete such reservoir and the parties thereto by mutual agreement have deferred the organization and capitalization of a corporation as contemplated in said agreement pending a practical demonstration by the party of the first part of the operation of said reservoir for the purpose of determining the cost and the best method of such operation and as a result of such demonstration and to establish a method of operation less burdensome to the party of the first part than the plan called for in said agreement the parties are desirous of modifying the terms of said agreement so that until otherwise determined as hereinafter provided said reservoir shall be operated by the party of the first part under the direction of the Riparian Company and the party of the first part relieved of the payment as provided in said agreement of a principal capital fund, the income from which would be sufficient *inter alia* to meet the cost of such operation; and

WHEREAS the Riparian Company has been organized by the parties of the second part to carry into effect the purposes contemplated in said agreement as herein modified and the party of the first part has paid to the parties of the second part, for the purpose of defraying the expenses incurred and to be incurred in connection with the consummation and execution of this agreement and the organization of the Riparian Company, the

sum of Two Thousand Seventy-five Dollars ($2 075.00), receipt of which is hereby acknowledged by the parties of the second part; and

WHEREAS the parties of the second part, other than the Riparian Company, since the execution of said agreement of May 1, 1911, have acquired and developed and may hereafter acquire and develop riparian rights and water power on said Farmington River in addition to the riparian rights and water power then owned by them respectively and it is desired to clearly extend the operation of the agreements now or heretofore made between the parties hereto, to the rights, power and developments now or hereafter made by said riparian owners;

NOW, THEREFORE, the parties hereto, each in consideration of the premises, of the respective undertakings of the parties to said agreement of May 1, 1911, as herein amended and modified, and of the undertakings of the other parties hereto herein contained, hereby agree as follows:

The Board of Water Commissioners agrees to maintain and keep in repair said reservoir, its structures and appurtenances, including the gates thereof, in such manner as will insure the preservation of said reservoir, its structures and appurtenances and the maintenance of the gates in suitable condition for proper control at all times of the waters thereof; and further agrees that it will not take any of the waters of the east branch of the Farmington River or of its watershed otherwise than for the purposes of said reservoir and that it will not in any manner divert such waters from the Farmington River.

The Board of Water Commissioners agrees to pay all taxes assessed upon said reservoir and its appurtenances when due and that it, the Board of Water Commissioners, will not sell or otherwise alien said reservoir or any flowage or other rights appurtenant thereto without the consent of the Riparian Company and each of the riparian owners aforesaid.

The Board of Water Commissioners agrees to reimburse the Riparian Company, upon presentation quarterly or semi-annually as said Company may elect of statements duly verified by its Treasurer, for the actual cash disbursements of said Company for all taxes and license and filing fees paid to the United States or the State of Connecticut and for its reasonable charges or clerical service in keeping its corporate records and in preparing and filing its corporate reports and/or returns required by law.

The Board of Water Commissioners shall be and remain the owner of said reservoir which shall continue to be its property notwithstanding the provisions of this contract, and the Board of Water Commissioners shall be liable for all loss, cost and damage resulting to the Riparian Company or to any person or persons, corporation or corporations whatsoever, for any failure of said reservoir, its structures or appurtenances, to safely hold and distribute such waters as may fall, flow and accumulate therein, and the Board of Water Commissioners shall indemnify and save harmless the Riparian Company and the contracting riparian owners from and against any loss, cost or expense incurred by reason of any claim, demand, suit at

law or equity, or any judgment therein in favor of any riparian owner or owners upon the Farmington River or the east branch thereof below said reservoir by reason of the construction or maintenance of said reservoir or the ponding of the waters therein.

Each of the riparian owners aforesaid shall have the right both against the said Board of Water Commissioners and the Riparian Company to the reasonable use of said compensating reservoir in such a manner as to hold back the waters of the Farmington River during seasons of high water and release them into said stream at periods of low water in a reasonable manner so as to increase the flow of said waters in dry seasons and thus enhance the value of the water power privileges of the owners signing this agreement.

The Board of Water Commissioners agrees to operate said reservoir for the use and benefit of the Riparian Company and said riparian owners and to that end to control the flow of the waters from said reservoir and to regulate the gates thereof in accordance with the requests and directions of the Riparian Company in so far as such control and regulation shall not interfere with the safety and integrity of said reservoir, its structures and appurtenances, and to employ such servants and agents and to do such acts and things, including maintenance of suitable telephone connections, as will insure the opening and closing of the gates, the measurement and report of the flow, and in general the operation of the reservoir in conformity with the reasonable requirements from time to time of the Riparian Company.

The Board of Water Commissioners shall have the right upon six (6) months' written notice to the Riparian Company of its intention to terminate its undertakings as contained and defined in the preceding paragraph, it being expressly provided, however, that in the event of such notice of intent to so terminate and prior to such termination or in the event that without such notice the Board of Water Commissioners shall fail to fully perform its undertakings in said paragraph contained, then and in either event the Riparian Company shall have and may exercise the right and privilege forthwith and thereafter to operate said reservoir, to control the flow of the waters therefrom, to regulate the gates thereof, to install and operate weirs for water measurement, and to do all such acts and things and exercise all such powers as will in the judgment of the Riparian Company be necessary to secure to itself and said riparian owners the full use and benefit of said reservoir and the Board of Water Commissioners will forthwith on demand of the Riparian Company pay to the Riparian Company a sum of money which invested at 4% will produce an income sufficient to enable the Riparian Company to properly operate said reservoir for the uses and purposes aforesaid, such principal amount to be by the Riparian Company invested and treated as a capital fund contributed for its corporate purposes, together with such further sum as will reimburse the Riparian Company for any expense it may have incurred or for any damage it may have suffered by reason of any failure of the Board of Water Com-

missioners to perform its undertakings in said paragraph contained prior to its payment to the Riparian Company of such principal sum aforesaid.

In case the parties hereto are in disagreement as to whether or not the Board of Water Commissioners has fully performed its undertakings as aforesaid in respect to the operation of said reservoir or in case the parties hereto are in disagreement as to the amount of the principal sum required to be paid by the Board of Water Commissioners to the Riparian Company as provided in the preceding paragraph, then the question of such default and the extent thereof and/or the principal sum aforesaid shall be determined by three arbitrators, one to be appointed by the Board of Water Commissioners, one by the Riparian Company, and the third to be chosen by the two arbitrators thus appointed, and in default of agreement by said Board of Arbitrators said parties shall be remanded to their rights at law or equity, including their rights under this contract.

The riparian owners at their joint option may at any time hereafter amend the Articles of Association of the Riparian Company and/or may cause to be incorporated and organized under any law, general or special, of the State of Connecticut another corporation to succeed to the corporate and/or contractual rights of the Riparian Company, and upon due notice to the Board of Water Commissioners of the transfer and assignment to such successor corporation of the rights hereunder of the Riparian Company such successor corporation shall be deemed to be substituted hereunder for the Riparian Company and shall thereafter have and exercise any and all rights and powers hereunder of the Riparian Company. The riparian owners in lieu of action by the Riparian Company or such successor corporation may at any time by their joint action exercise any power and enforce any right which under the provision hereof the Riparian Company may exercise or perform.

The provisions of this agreement shall be and be deemed to be in amendment and substitution for the provisions of paragraph marked "Second" (including subdivisions 1, 2, 3 and 4 thereof) and paragraph marked "Third" of said agreement of May 1, 1911, and subject to such amendment and substitution the parties hereto hereby ratify and confirm said agreement of May 1, 1911.

To the faithful performance of its agreements and undertakings herein the Board of Water Commissioners binds itself and its successors to and in favor of the Riparian Company and to and in favor of such riparian owners respectively, their successors and assigns, and this contract shall inure to the benefit of said riparian owners, severally, and to their respective successors and assigns.

IN WITNESS WHEREOF the parties hereto have caused these presents to be signed by their duly authorized officers and their corporate seals to be affixed hereunto and to four duplicates hereof at Hartford, Connecticut, as of the day and year first above written.

Discussion.

Charles W. Sherman.* It is difficult to adequately discuss a paper of this kind, even with the data available upon which it is based; and about all that can be presented in an extemporaneous discussion is in the line of generalities.

Mr. Saville has obtained and tabulated some of the essential statistics of the more recent awards and settlements for water-power diversion, which will be of great value.

A committee of this Association made a very elaborate investigation, with a detailed report, in the year 1909, giving the records of all available settlements for water-power diversion in New England and New York, and some parts of Pennsylvania, from the beginning of such records to the date of their report. Those figures have been of great use in all settlements of this kind since that date; but of course many settlements have been made since, and the change in the value of the dollar has somewhat altered the basis of settlement. Consequently it is of great interest to have further data, and more up-to-date data, made available.

I have had personal contact with two settlements since the date of that report, which are of some little interest. One was for the city of Fitchburg, the city which successfully put through a case of "compensation in kind" in one of its earlier cases. In this particular case the mills especially affected were very close to the point of diversion, and the physical conditions were such that it was possible to build another reservoir for mill use almost immediately below the one that was built for the water supply. The drainage area was not large, but it was sufficient for the purpose, and the compensating reservoir has been operated satisfactorily since that time. If I remember rightly, there was something like one and one-quarter square miles of drainage area. The mills down on the Nashua River into which this tributary flowed really were not interested in it. They were not sufficiently damaged physically, whatever they might have claimed legally, to care to enter into the question, so that they did not enter into the agreement and have never made any claims against the city.

About ten years ago a further addition to the water supply of Fitchburg became necessary, and, based on their previous experience, the city officials felt that they ought to be able to negotiate an agreement for compensation in kind with the mill owners. When conversations with the mill owners started the latter were very positive in saying it was not money they wanted, but water. An attempt to negotiate an agreement for such compensation was made but it did not seem possible to work out anything certain in advance. The mill owners did say, in effect, "we think it will be all right; go ahead and build the reservoir and we will see how it works"; which the city did, and very shortly thereafter suits were brought by all the mill owners, and the matter took the usual course through the courts and awards were made. Just how far the arbitrators — two engineers who fixed all damages — took into account the value of the compensation

*Of Metcalf & Eddy, Consulting Engineers, Boston, Mass.

reservoir, I never was able to learn. I know they said that they took it into account. And I also know that when you figure the total damages paid and add the cost of the reservoir, the total cost to the city was not excessive, so that perhaps it was fair. But the "compensation in kind" as such seemed to be a failure in that case. One great trouble was that on this stream the mills affected, instead of being concentrated rather closely to the point of diversion, were scattered along the stream for quite a long distance, and what would be adequate compensation in kind for the mill nearest the point of diversion, did not amount to anything to speak of to a mill 15 miles farther down the stream; consequently there was no suitable basis upon which the various mills affected could agree upon the operation of the compensating reservoir. When a mill close to the point of diversion would want to use the water in the reservoir, a mill farther down the stream would want to store it for a further time. That is merely an illustration of the difficulty of working out a compensation-in-kind agreement.

A somewhat similar difficulty was obvious in a case in this present year where the city of Leominster has made takings for an additional water supply, and where, although compensation in kind was not worked out an agreement satisfactory to all parties was reached without litigation. In this case the water taken was at a large storage reservoir built by the mill owners many years ago, which the city now proposes to utilize. The fall of the stream below that point and within the city of Leominister was considerable. With only one or two minor exceptions the privileges were the property of mill owners who composed an association which owned and operated the old reservoir, and an agreement was made with those mill owners jointly, after getting them into conference and discussing the matter. The city laid all its cards on the table; all its information was laid before the mill owners, and they agreed unanimously to the basis of compensation in money. In this case, the mill owners were to receive a definite sum per foot of fall available to them, with the exception of the privilege nearest the reservoir, an electric generating station, which it proved more advantageous for the city to buy outright, as the real estate and other property was wanted. That, as between the several mill owners, was not absolutely equitable, because the water power was more valuable to some than to others, principally because of their more advantageous pondage. But it seemed to be the only basis which could be worked out as common between them all, and the differences, while noticeable, were not sufficient to warrant overthrowing the agreement.

One prime advantage in negotiating this agreement, was that the chairman of the Water Commissioners was also a member and one of the officers of the Reservoir Association, being one of the manufacturers of the city. He was anxious to do his best for the city, and he was also anxious to get fair treatment for his own mill and for the other mills associated with him; and the mill owners knew that one of their own number was on the inside and were assured by that means, even if they had not trusted the good faith of the city, that they had all the information.

PROCEEDINGS.

The following is a synopsis of such parts of the proceedings at the Providence convention as appears to be of value for the record.

Forty-fifth Annual Convention.

Providence, R. I.,

September 14–17, 1926.

The Forty-fifth Annual Convention of the New England Water Works Association was held at Providence, R. I., September 14–17, 1926.

The technical sessions of the Convention were held in the ballroom on the fifteenth floor of the Biltmore Hotel, the exhibits of the Associates being placed in the foyer adjacent to the ballroom.

Morning Session, Tuesday, September 14.

The President, Theodore L. Bristol, in the chair.

President Bristol. At this opening of our Forty-fifth Annual Convention it certainly seems as if we were nearing the half-century mark in the life of our Association. Our meeting here in Providence is at the invitation of one who I hope will be the next president of our Association, — Mr. Frank E. Winsor,— who is the chief engineer of the Water Supply Board of Providence. I know that as chairman of the local committee he has done everything that should be done to make our Convention a success. He has been ably assisted, and I am sure that if you find there is anything wrong with the arrangements he will be very glad to have you call it to his attention and he will see that everything is made all right for us.

It is my part of the program to introduce Mr. Winsor, although he needs no introduction, and he will introduce those who have honored us by their presence to welcome us. Mr. Frank E. Winsor. (*Applause.*)

(*Addresses of Welcome.*)

Frank E. Winsor. Mr. President, members of the Association, and guests: It is a great privilege to welcome you on behalf of the local committee of Providence and to express the hope that you will enjoy your stay and that some of our kind friends will have a pull with the weather bureau and arrange for two more days such as this now promises to be. You had a brief inspection trip to Providence a year ago, you know what the country looks like under other conditions, and we hope this time you will see it with a little sunshine.

The Association is greatly honored by the presence here of representatives of the State, of the City, of the Chamber of Commerce, and of the

Water Supply Board; all of whom will have a word of welcome to say to you. Perhaps, as some of you may remember, two years ago in this State we had a little disagreement up at the State House, as the result of which some of our Rhode Island statesmen went up among the Massachusetts hills for a few months. One of the results was that the statute books were not encumbered with a lot of useless legislation, although there were some things they might have done which some of us would have been glad to have seen done if they had seen fit to stay here through the session. As the result of the last election a change occurred so that everything has been peaceful and harmonious since that time.

A few weeks ago a fire occurred in one of our large apartment houses. The fire department responded and found that everyone had escaped except one very heavy woman, who was hanging out of an upper window. They put up a ladder, which failed to reach the top. A lone fireman climbed to the top but he could not reach the window. He called, "Jump, lady! I will catch you." She jumped. He flattened himself against the ladder and let her go by. Upon later being questioned by his chief as to why he behaved in that manner he said, "Why, I expected to catch her on the bounce, but she did not bounce." (*Laughter.*)

Some few weeks ago a serious strike situation threatened this State. The Governor did not wait for the bounce but took such action that the crisis came to an end almost before it had occurred.

I greatly regret that Governor Pothier is not able to be with us this morning, but he has sent his able lieutenant, and I am very much pleased to introduce to you Mr. John Bennett, Secretary to the Governor. (*Applause.*)

(*Remarks by Mr. John Bennett.*)

Mr. President, Mr. Honorable Mayor, distinguished guests, ladies and gentlemen: It is my pleasure this morning, in the absence of His Excellency the Governor, to extend to the delegates of this Convention the Governor's felicitations and best wishes and a cordial welcome within our borders on behalf of the citizens of our State. Rhode Island is proud to have within our borders at any Convention such a distinguished group of ladies and gentlemen as I see before me now. It is many years since we have had such a distinguished group. We are sure that your stay here will be pleasant.

We have many points of interest, many industries. As you know, we are the industrial State. After tours of inspection conducted through our State, I believe by the time you arrive back at your native State you will be convinced that your time has been well spent here. We trust that when you go back you will carry with you pleasant recollections of your visit here; that you will carry back pleasant memories of some of the friendships which were created here, and that you will have an opportunity at some future time to come back and visit our State again.

One of the interesting things that you will see on your tour of this State is the Scituate Reservoir. I understand that you are to pay that spot a visit on Thursday. Rhode Island is proud to have such a project so near completion as that reservoir. Rhode Island is proud of the chief engineer whose great ability has brought that thing to almost completion,— Rhode Island is proud of Mr. Frank Winsor. We owe him a great deal. The city of Providence in particular owes him a great deal. We regret that Mr. Winsor is soon to leave us. His reputation has grown throughout the State and throughout the country, and he has been called to do some similar work in Massachusetts. We regret exceedingly that he must leave us, but we rejoice that he is perhaps bettering himself.

So, my friends, when you visit our State, take in the many historic spots, and when you go back to your native States, do not forget where Rhode Island is, and try to recall those pleasant things and the pleasant time that you had within our borders. (*Applause.*)

MR. WINSOR. Years ago there used to be competition, I understand, — which perhaps some of the older inhabitants can remember,— for the office of mayor of the city of Providence. In late years, since I have been here, there apparently has been no competition. For the last eleven years the present Mayor has also served as a member of the Water Supply Board, where he has been a most efficient and valuable member. I think that the time which he may remain in office depends entirely upon himself, for as long as he is willing to sacrifice himself, it is evident that his fellow citizens will keep him in office. I am reminded of the story of the man just returned from the burial of his mother-in-law. When asked, "What was the complaint?" he answered, "No complaint; everybody satisfied." (*Laughter.*)

It gives me great pleasure to call upon Mayor Gainer. (*Applause.*)

(*Remarks by Hon. Joseph H. Gainer, Mayor of Providence.*)

Mr. Toastmaster, Mr. President, Officers of the Association, fellow-workers, and ladies and gentlemen: It is indeed a very great pleasure as Mayor of the City of Providence to extend to you all, officers, delegates, and such ladies as have come with you, a very sincere and a very hearty welcome to our municipality. I have taken the precaution to see the weather bureau, and if the next two days are not as satisfactory as this one is, it is their fault, not mine.

We appreciate very much your having selected Providence as the place of meeting for your Forty-fifth Annual Convention. We realize from the nature of your gathering, from its membership, and from the list of speakers, that we are to have a treat during the next few days. We are to have a discussion which will be very helpful and very interesting. In return we hope that we may be able to partially reciprocate by being slightly helpful to you.

As has been indicated, Providence is an old city, as we speak of time

in the United States of America. Historically, industrially, educationally, and commercially we think we have many things which are of interest to visitors. Fortunately we have about completed, or largely completed, the main features of the new water development. It will cost us, as you perhaps know, something like $21 000 000; and if unforeseen accidents do not happen, unforeseen obstacles do not occur, we expect to complete this project within two years.

I suppose most of you know the main features of this project. It consists of a great reservoir, about 3 600 acres, a main dam 3 200 ft. in length, with a height of about 100 ft. above the valley, a dike 4 000 ft. long, an aqueduct about 7 miles in length from the gate-house in the dam to the present distribution system, a purification plant of the rapid sand type, two distribution reservoirs,— one for low and one for high service,— and a pipe line connecting those reservoirs with the main system. The pipe line and the two reservoirs have not as yet been completed. About all the rest of the work has been completed, for all practical purposes.

I think it is an interesting thing — I will call your attention to it because it strikes me as interesting — that the area which we have taken for this new water development is larger than the municipal area of the city of Providence. The area taken for the reservoir is about 23 sq. miles; the area of the city of Providence is 18 sq. miles.

This work has been carried on by an unpaid Board of which B. Thomas Potter, a gentleman who will speak to you this morning, is chairman. Up to date no responsible citizen has charged graft or waste in connection with the work. We feel very proud of that. They have not discovered anything yet, anyway. (*Laughter.*)

We have had the best engineering brains of the country, we think, in consultation on this work. We have had the late Samuel M. Gray, a local man but whose reputation was widespread; we have had the late Frederick P. Stearns of Massachusetts; we now have on our list J. Waldo Smith of New York, Allen Hazen, the filtration expert, and Charles T. Main. But the man who is most responsible for whatever we have done here is the chief engineer of our work,— Frank Winsor. (*Applause.*)

I would just like to say to you gentlemen that we believe Frank Winsor is not only one of the ablest water engineers in this country, but he is an unusual, an exceptional executive. He is a thorough gentleman and he is a man who knows how to work with men. He has been a wonderful help to our Commission, and although we have had rather a large body we have not had a serious disagreement during the progress of this work; and that was due, largely to the tact, talent, and ability of our chief engineer. We are very sorry to see him leave Providence, but, as has been said, we are glad to see him better himself. But he was such a gentleman and so fair he would not leave us before he put it up to the Board, and he would not actively seek the other position until we unanimously assured him that we would not stand in his way for a better opportunity. The credit for this

work — and we think it is a very splendid project, that we have got one of the best water developments in this country — the great credit for this work goes to Frank Winsor, and I want to compliment him this morning. (*Applause.*)

I want to compliment Mr. Winsor on another thing, and that is that he is going to leave an organization that can carry on this work after him, which shows his ability as an executive. His deputy engineer is taking charge of the work and we feel confident that he will carry it on for the next two years to a successful conclusion.

But I must not talk to you technically because you have so many technical men who will dissect and analyze and partition this work to your satisfaction that it would be presumption on the part of a layman to attempt to discuss it in detail. I see from your program that you have a very interesting social time planned for the various days. We want you to stay here during the whole program; we want all of you to stay in order that you may enjoy this program and in order that you may know us in Providence as we want you to know us. And again let me assure you that we are very, very happy to have you with us, and very happy to be your hosts. (*Applause.*)

MR. WINSOR. This Convention is indebted to many individuals and to many associations for much that we hope will render it successful, and one of the associations that has been particularly helpful to us is the Providence Chamber of Commerce, and the president of that body will next welcome you.

Most men have some kind of hobby. With some it is golf, with some it is baseball, with some it is pitching horseshoes, with some it is poker, with some it is bridge. Others may have a hobby for swimming the English Channel, which seems to have become popular these days. But the hobby of the next speaker is unusual. I do not know that he realizes that it is a hobby; it may be that it is only his friends that make it his hobby. But do you know, I expect to wake up some morning and read in the headlines of the newspapers that the next speaker has been elected president of the universe! He is at the head of more organizations than any other individual whom it is my pleasure to know.

There was a certain Jew of this town who settled in an Irish neighborhood, and he named his son Abraham Patrick Cohen. Upon being asked the reason for such a name he explained, "Abraham is for his grandfather, and Patrick is for protection." (*Laughter.*)

Now, some of these organizations of which the next speaker is president, I understand, are for protection. Perhaps he will tell you about that. The next speaker, I believe, is President of the Providence Chamber of Commerce, President of the Providence Y. M. C. A., President of the Providence School Board, and a leader in many other patriotic and fraternal organizations.

It is my great pleasure to call upon Mr. William L. Sweet.

(Remarks by Mr. William L. Sweet.)

Mr. President, Mr. Chairman, Mr. Mayor, Members of the New England Water Works Association, and guests: I scarcely know where to begin, as I never do when I follow the Mayor of the City of Providence, as I have on some occasions in addressing conventions of this character. About all that can be said is usually said by our Mayor, and I am very glad that the chairman of this meeting has introduced the Mayor in such a pleasant way in order that you may know him and know of the great work which he and his associates are carrying on in the city of Providence. As President of the Chamber of Commerce of the city of Providence, it is a real pleasure to me to extend to you the very heartiest welcome of the business interests of the city. The Chamber of Commerce is unusually interested in welcoming men and women from other parts of the country. We feel in the city of Providence that we have a large industrial center, large business center, and we are very proud of it, and we like to have others come here and see what we have. We like to have them come here, and we always gather information from them to the betterment of our industry and to the betterment of the business interests.

You are members of a profession prominent in the industrial world, — a very necessary profession. Some of you have many branches of engineering. About a year ago it was our pleasure to entertain here the American Institute of Chemical Engineers, and possibly some of you were present on that occasion. We had a delightful time with them, we did everything we possibly could to make their stay a pleasant one, and it is our intention this time while you are with us to do everything we possibly can to make your visit to Providence a real event in your lives.

The Chamber is always interested in men who accomplish things. I know of no profession that accomplishes more, whose members accomplish more, than the members of the engineering profession. They are particularly active in bringing about better industrial conditions. Not only in that line are they active but they are active in connection with the health of our communities, and you men who are particularly interested in the water supplies of our various communities are adding to the years of the people of those communities; which is a really great accomplishment because there is nothing so important as the water of a community, and our Mayor has told you what extensive arrangements we have been making during the past few years to provide the city of Providence with a proper amount and a proper purity of water.

I think I will not take more of your time. I want to again thank you for coming to Providence. I am hopeful that the Chamber may in some way be of service to you. Our headquarters are in the center of the city and in one of the oldest buildings in the city of Providence. I think you will enjoy, if you have a moment, coming there, going through and seeing that wonderful old building of which the people of the city of Providence are very proud. Our Secretary is there always. He will be in and out

among you, as I hope to be myself, and anything that we can do to render your stay in Providence pleasant and comfortable I hope you will not hesitate to call upon us for.

I thank you for the opportunity, Mr. Chairman, of addressing your distinguished gathering. (*Applause.*)

Mr. Winsor. About thirteen years ago the City Council of Providence appointed a committee to study the problem of an additional water supply. That committee was appointed from members of the then City Government and continued to serve for about two years, and as the result of their labors legislation was secured in April, 1915, whereby the then committee was legislated into office as a water-supply board. It is rather remarkable that after eleven years those same seven members are still members of the Water Supply Board, and that the work has been conducted during those eleven years without any change in the Board. Not only is that remarkable, but it is remarkable that a board of seven men could have been found who would devote of their time and talents for eleven years in conducting a work which, as the Mayor has told you, will run into around $21 000 000 of expenditure, without any compensation. I believe it is a record that is unequaled in this country or elsewhere. I know of no similar record, and I hope that the citizens of this town will sometime appreciate the work that this Board has done.

Not only have we had one board but we have also had one chairman. I suppose when this work began, back in 1913, under the original committee appointed by the council, they might have felt somewhat as Lord Nevis of England felt when he wrote this little poem:

> "Pure water is the best of gifts that man to man can bring;
> But who am I that I should have the best of everything?
> Let princes revel at the pump, let peers with ponds make free,
> Whiskey, wine, or even beer, is good enough for me."

(*Laughter.*)

Whatever may have been the feelings of the Board originally, with the passage of the 18th Amendment and other changes which came about their sole ambition for many years has been to bring to the city of Providence the very best water supply that it is possible to obtain, and I believe that you will agree with me, after viewing the work, that they are about to realize their ambition.

I have been associated with the Board and with the Chairman for eleven years and I want to testify to the uniform courteous treatment I have received and to the very pleasant relations that have existed in all that time. I am greatly pleased to call upon Mr. B. Thomas Potter, Chairman of the Water Supply Board. (*Applause.*)

(*Remarks by Mr. B. Thomas Potter.*)

Mr. President, Mr. Toastmaster, Ladies and Gentlemen: After having been welcomed by all of the "big guns," — the representatives of the State,

the City, the Chamber of Commerce, — a common powder cracker cannot be expected to create much of a sensation.

I am not going to try to tell you anything about the water development — the Mayor has touched on it, and Mr. Winsor and others will probably elaborate on that description later on. But I want to say to you, on behalf of the Water Board, that we are very pleased, very happy to have you here and to be able to show you the wonderful 100 per cent. up-to-date water development which we have.

I think the Board and the citizens fully appreciate the great debt that we owe to the engineer for making this project possible, because without the engineer it never could have been accomplished.

I hope that you will remain in the city as long as the entertainment and your funds hold out, and when they are exhausted I hope you will go home with a very happy memory of your visit here and that you will commence to save up for a return. (*Laughter and applause.*)

PRESIDENT BRISTOL. Gentlemen, we thank you very much for your welcome to us, and we thoroughly appreciate your coming here to extend that welcome. This applies to the representatives of the State, the City, the Chamber of Commerce and the Water Board. We also wish to express our great thanks to Mr. Winsor for having this welcome here for us.

The Secretary, Frank J. Gifford, submitted his annual report (See page 406.)

The Treasurer, Albert L. Sawyer, submitted his annual report. (See page 409.)

The Editor of the JOURNAL, John P. Wentworth, submitted his annual report. (See page 412.)

The report of the Finance Committee was read by George A. Sampson. (See page 415.)

The report of the Committee on Standard System of Sanitary Scoring of Water Supplies was presented by E. Sherman Chase. (See page 416.)

THE PRESIDENT. The next business is the closing of the polls. Have all voted for the officers who wish to do so? (*No response.*) If so, I will declare the polls closed and appoint the tellers as follows: A. R. Hathaway, George A. King, George F. Merrill.

TUESDAY AFTERNOON, SEPTEMBER 14.

The Secretary announced the election to membership of the following: Francis H. Kingsbury, Medfield, Mass.; Fred W. King, West Warwick, R. I.; George D. Dame, Rochester, N. H.; Charles E. Gardner, Providence, R. I.; William Storrie, Toronto, Canada; George L. Hathaway, Wareham, Mass.; Edward L. Randall, Wrentham, Mass.; Frank E. Hussey, Rochester, N. Y.; Owen J. Eagan, Somerset, Mass.; Anson W. Squires, Tampa, Fla.; Alfred Gildersleeve, Portland, Conn.; George B. Raymond, Danbury, Conn.; Frederick W. Cotter, Derby, Conn. *Corporate Membership:* Glens Falls Board of Water Commissioners, Glens Falls, N. Y.

A paper on "The Methods of Treatment of the Providence Water Supply," was read by Julius W. Bugbee, City Chemist, Providence, R. I.

A paper on "The Pumping Stations of the Providence Water Works," was read by James A. McKenna, Engineer, Water Department, Providence.

Award of Dexter Brackett Memorial Medal.

THE PRESIDENT. We will now take up the matter that was held over from this morning, namely, the award of the Dexter Brackett Memorial Medal, and Mr. George A. King, the Chairman of the Committee, will make the award.

GEORGE A. KING. Mr. President, the founders of the New England Water Works Association were a group of water-works officials, soon joined by others. About three years after its organization, Dexter Brackett, a young man in his early thirties, joined the Association and soon rose to a prominent position in the ranks and became a leader in the affairs of the Association. His life work was in connection with the distribution system of the city of Boston and the Metropolitan District. He made studies of the various water problems which came up, and took part in the discussions of this Association. He was a man of sound judgment and broad view, which made his advice to others, which he freely gave, of great value.

I was thinking of the kindly spirit of Mr. Brackett, and I noticed that in the tribute of the Association to his memory the Committee referred to that characteristic, and two of the four letters from his early associates referred to that trait. For several years prior to the death of Mr. Brackett, which occurred in 1915, at Marston's restaurant in Boston a table was reserved for the engineers. Luncheons had not become so prominent at the City Club. Last winter the engineers had an early dinner in the evening at Marston's and at one of them which I attended I thought that the face of the waitress was familiar, and I recalled that she was one who waited on that engineers' table so many years ago, and she confessed that she was; and then, without any prompting, she referred to Dexter Brackett and his kindly manner.

Mr. Brackett was very much interested in the Association, its JOURNAL, and its members, so that on his passing it was a general desire to preserve the memory of what he had done for the Association, and a fund was created the income of which should go to provide a medal to be presented to the member who should give the best paper published in the JOURNAL during the year, thus helping to advance the interests of the Association by improving its JOURNAL, inciting the members to write for it, and also to preserve the memory of Mr. Brackett and to recall his spirit of helpfulness so worthy of emulation.

The Committee on the award for last year found a great many valuable papers, but after a little consideration they found that the writers of several of them were not eligible for the medal as they were not members of the Association. There were two points that we had to consider,— the

value of the paper and the number of members who would benefit by its perusal. We were under some difficulty in arriving at our verdict, but there was one paper that we considered met these two conditions more than the others, and that was the paper we recommended for the award. It was the paper of Mr. John F. Laboon of Pittsburgh, Penn., entitled "Features of the Wheeling, West Virginia, Water Works Filtration Plant and Operating Results."

Mr. Laboon, we take great pleasure in presenting you this medal in appreciation of what you have done for the Association. We hope that you will continue your interest in the Association and that the medal will remind you of one who added to his distinguished ability the spirit of helpfulness to others.

JOHN F. LABOON. Mr. President, Mr. King, Ladies and Gentlemen: I wish to say that I thank the Association most heartily. I appreciate this honor immensely. This occasion shall ever remain in my memory. (*Applause.*)

A paper on "Water Main Distribution and Maintenance of Providence Water Works," was read by S. Frank Nolan, Superintendent of Water Distribution, Providence. Messrs. J. P. Miller, Stephen H. Taylor, Hugh McLean, Percy R. Sanders, Roger W. Esty, Henry T. Gidley, John F. Laboon, James A. McKenna, Edward D. Eldredge, Albeus P. Murray, and Frank E. Winsor took part in the discussion.

A paper on "The Method of Reading Meters, Billing and Collecting Revenue of Providence Water Department," was read by Albeus P. Murray, Superintendent of Meters, Providence. George F. Merrill, Hugh McLean, W. C. Hawley, Henry T. Gidley, and Edward D. Eldredge participated in the discussion.

A paper on "Some Recent Applications of the Venturi Principle" was read by F. N. Connet, of the Builders Iron Foundry, Providence. Professor Charles M. Allen made some remarks on the topic.

A paper on "Some Factors Affecting the Loss of Head in Rapid Sand Filters" was read by R. G. Tyler, Professor of Sanitary Engineering, Massachusetts Institute of Technology, the paper having been prepared by Professor Tyler in conjunction with Major W. A. Danielson and Maurice Le Bosquet, Jr., Graduate Students.

TUESDAY EVENING, SEPTEMBER 14.

A paper entitled "Linings and Coverings for Water Pipes," prepared by Benjamin Talbot, Middlesbrough, England, was read by John L. W. Berkinbine. Messrs. Stephen H. Taylor, Charles W. Sherman, Albeus P. Murray, William R. Conrad, and David A. Heffernan took part in the discussion.

The remainder of this session was occupied in a discussion on topics of interest to superintendents, Messrs. Charles W. Sherman, George F.

Merrill, David A. Heffernan, Henry T. Gidley, William A. MacKenzie, Samuel E. Killam, Roger W. Esty, Charles Haydock, Caleb M. Saville, Arthur C. King, Edward L. Randall, G. E. Hawkins, George A. King, Samuel J. Kyle, C. Dwight Sharpe, Stephen H. Taylor, Frank E. Winsor, Albeus P. Murray, Harry A. Burnham, and Malcolm Pirnie participating.

Wednesday Morning, September 15.

A paper on "Laws and Regulations for the Protection of Public Water Supplies" was read by Warren J. Scott, Director Bureau of Sanitary Engineering, Connecticut State Department of Health. The discussion was participated in by Messrs. Arthur H. Pratt, Robert Spurr Weston, Charles W. Sherman, Stephen H. Taylor, Harry A. Burnham, Stephen DeM. Gage, W. W. Hatch, C. W. Mowry, Percy R. Sanders, C. Dwight Sharpe, William A. MacKenzie, M. N. Baker, Caleb M. Saville, and Richard H. Ellis.

Upon motion of Caleb M. Saville, as amended and seconded by Charles W. Sherman, it was

Voted: That the President appoint a committee to consider the matter of double-check valves connecting polluted water supplies for fire-protection purposes with public water supplies, and to report their findings at one of the winter meetings of the Association, said appointment to be deferred until after the executive committee has met and considered the matter and made such suggestions as it desires regarding personnel of the committee and methods in which the Association shall receive and act on the report.

A paper on "Principles of Rate Making" was read by William M. Wherry, Counsellor at Law, New York City. Caleb M. Saville, Malcolm Pirnie, W. C. Hawley, and A. C. Dickerman took part in the discussion.

A paper on "Observations Abroad of Interest to Water Works Men" was read by Charles W. Sherman, Consulting Engineer of Metcalf & Eddy, Boston. Mr. M. N. Baker made some remarks on this subject.

Wednesday Afternoon, September 15.

There was no technical session of the Convention on this afternoon. Automobile trips were taken to various industries, including Builders Iron Foundry, General Fire Extinguisher Company, and Gorham Company; as well as through the Providence parks, through Brown University, and the Rhode Island School of Design.

Wednesday Evening, September 15.

A paper on "Mechanical Ditch Digging," illustrated by moving pictures, was read by Earle F. Lamprey of the Barber-Greene Company.

A paper on "Chlorine Studies and Some Observations on Taste-Producing Substances in Water, and the Factors Involved in Treatment by the Super- and De-chlorination Method," prepared by Norman J. Howard, Bacteriologist in charge of Water Purification, and Rudolph E. Thompson, Assistant Chemist, Filtration Plant Laboratory, Centre Island, Toronto, Ontario, was read by Mr. Howard.

A paper on "The Theory and Use of Thermit Heat Units in Relieving Ice Troubles" was read by Dr. Howard T. Barnes, Professor of Physics, McGill University, Montreal, Canada. Dr. Barnes was introduced by Mr. John Ripley Freeman. The discussion following the presentation of paper, which was illustrated by stereopticon slides, was participated in by Messrs. Charles W. Sherman, M. A. Sinclair and Allan F. McAlary.

CHARLES W. SHERMAN. There is one thing which I think ought not to be passed without a little further thought. Dr. Barnes has very kindly suggested that he would be glad to coöperate with this Association or its members in some tests on frozen hydrants. Of course the Association is rather a large and unwieldy body to try to coöperate unless some special organization is formed to do something, and I therefore want to move that the President, with the advice of the Executive Committee, appoint a committee of such size as he thinks best to see what arrangements can be made towards carrying out some of the experiments which Dr. Barnes would like to make.

(The motion was duly seconded and carried.)

A paper on "Making Pipe Centrifugally in a Refractory Mold," illustrated by motion pictures, was read by E. W. Herrmann of the American Cast Iron Pipe Company.

THURSDAY MORNING, SEPTEMBER 16.

A paper on "Mechanically Cleaned Sedimentation Basins for Water Works," prepared by Edmund B. Besselievre of The Dorr Co., Inc., was read by Nels B. Lund.

A paper on "Compensation for Stream Diversion for Municipal and Other Supplies" was read by Caleb Mills Saville, Manager and Chief Engineer, Hartford Water Works. Mr. Charles W. Sherman made some remarks on this subject.

A paper on "Some Phases of Chlorination" was read by William J. Orchard of the Wallace and Tiernan Co., Inc.

A paper on "Evaporation" was read by Robert E. Horton, Hydraulic Engineer, Voorheesville, N. Y.

A paper on "Scituate Dam and Dike" was read by Francis B. Marsh, Designing Engineer. Messrs. Frank A. Marston and C. Dwight Sharpe discussed the paper.

A paper on "Clearing and Grubbing Six Square Miles for the Scituate Reservoir" was read by William A. Reid, Resident Engineer.

A paper on "General Description of the Purification Works" was read by Walter W. Kittredge, Assistant Engineer, Providence.

THURSDAY AFTERNOON AND EVENING.

There were no technical sessions of the Convention on Thursday afternoon and evening. Shortly after 1 P.M., the party left Providence by automobile for an inspection trip over the new Providence Water Supply, after which stop was made at the Chopmist Hill Inn, Scituate, where one of the famous Rhode Island clambakes was served about 6 P.M. After the bake a blackface entertainment was given, followed by dancing.

The clambake and entertainment at the Chopmist Inn were by courtesy of the Water Works Manufacturers' Association.

FRIDAY MORNING, SEPTEMBER 17.

The Secretary announced the election by the Executive Committee of the following new members: George C. Danforth, Augusta, Me.; Michael J. Mahoney, Easthampton, Mass.; Malcolm Pirnie, New York City; G. E. Hawkins, Brattleboro, Vt.; Walter E. Merrill, West Somerville, Mass.; Edwin H. Arnold, Providence, R. I.; Albeus P. Murray, Providence, R. I.; Ralph H. White, Auburn, Me.; Thomas F. Wolfe, Chicago; Marshall B. Palmer, Syracuse, N. Y. *Corporate Membership:* City of Quincy Water Department, Quincy, Mass.

A paper on "Real Estate and Damage Settlements for 15 000 Acres Acquired for Scituate Reservoir" was read by Earl C. Craig, Assistant Designing Engineer.

A paper on "Some Details of Grouting and Preparing Foundations for Scituate Dam" was read by James V. Turner, Resident Engineer. Messrs. George F. Merrill, John P. Wentworth, and Karl R. Kennison took part in the discussion.

A paper on "Some Color Observations on Waters Tributary to the Scituate Reservoir" was read by Frederick O. Clapp, Assistant Engineer.

A paper on "The East Providence Water Company" was read by A. C. Dickerman, Superintendent.

A paper on "Scituate Tunnel" was read by Richard R. Bradbury, Resident Engineer.

A paper on "Scituate Aqueduct in Open Cut" was read by Thomas T. Allard, Resident Engineer. Mr. Marshall B. Palmer told of his experiences along this line.

THE PRESIDENT. There is another paper that we were supposed to have this morning, but owing to the lateness of the hour it will be only read by title. That is a paper by Thomas F. Wolfe, Research Engineer of the Cast Iron Pipe Publicity Bureau of Chicago, and the title of the paper is "The Purpose of the Cast Iron Pipe Publicity Bureau." This paper will probably be published in the JOURNAL but will not be read at this time.

Report of Tellers of Election.

Total number ballots cast ..... 299; blank, 1

President.

FRANK E. WINSOR 297

Vice-President.

ARTHUR D. WESTON 294

Directors.

SAMUEL H. MACKENZIE 290
GEORGE H. FINNERAN 289

Treasurer.

ALBERT L. SAWYER 295

GEORGE F. MERRILL, *Chairman*,
GEORGE A. KING,
GEORGE C. BREHM.

PRESIDENT BRISTOL. According to the ballot I will declare these gentlemen elected and our officers for the ensuing year. (*Applause.*)

I am very much pleased to know that we have elected Mr. Winsor, and to announce his election. I think it would be fitting if Mr. Winsor would make a short speech. (*Applause.*)

FRANK W. WINSOR. This call for me to make a speech is rather unexpected. I had to introduce some gentlemen a few days ago at the opening of this Convention — it seems some months ago now — and I got someone to write that speech for me, but this time I have not had any assistance and therefore I am discovered.

As I look back upon the illustrious predecessors in this office I am filled with a thought of my own inadequacy for the work, but I am in hopes that, with the indulgence of the Association and the help of the Board of Directors, I will in some way get by. You are to be consoled by the knowledge that this Association elects a new president every year.

I sincerely thank you for the honor and I hope the Association may flourish during the coming year. (*Applause.*)

STEPHEN H. TAYLOR. I wish to add my congratulations and best wishes to Mr. Winsor in his new position.

We have had a very pleasant Convention and a great deal has been done for us by the local people, and I would like to offer the following resolution:

Resolved, that the thanks of the New England Water Works Association are extended to His Excellency, Governor Pothier, His Honor, Mayor Gainer, the Providence Chamber of Commerce, and the Providence Water Supply Board for their cordial welcome and the many courtesies which they extended to the Association at its Forty-fifth Annual Convention.

(The motion was duly seconded and unanimously carried.)

DAVID A. HEFFERNAN. Mr. President, I would like to submit the following resolution:

Resolved, that the thanks of the New England Water Works Association are hereby extended to the Builders Iron Foundry, the General Fire

Extinguisher Company, Gorham Manufacturing Company, Narragansett Electric Lighting Company, Brown University, the Rhode Island School of Design, the Commissioner of Public Works of the City of Providence, Winston & Company, the City and State Police, the Biltmore Hotel, and the Chopmist Hill Inn; and also to many individuals who furnished and drove automobiles, acted as guides, and in other ways contributed materially to the interest and pleasure of the Forty-fifth Annual Convention.

(The motion was duly seconded and unanimously carried.)

GEORGE A. KING. We were very much pleased with the manner in which the officers and the privates of the police force and the state constabulary did their work. The drivers of the cars were very much pleased with the manner in which the officers performed their duties, and I therefore offer the following resolution:

Resolved, that the thanks of the New England Water Works Association are extended to the individual officers of the Providence and Rhode Island State Police who so efficiently handled the excursion of the Forty-fifth Annual Convention to the new water supply works at Scituate.

(The motion was unanimously carried.)

ARTHUR D. WESTON. I think we all feel that much of the success of the Forty-fifth Annual Convention has been due to the Water Works Manufacturers' Association, because of the very splendid entertainment which they were able to give us, and I therefore offer this resolution:

Resolved, that the thanks of the New England Water Works Association are hereby tendered to the Water Works Manufacturers' Association for the entertainment provided for its members and guests at its Forty-fifth Annual Convention.

(The motion was duly seconded and unanimously carried.)

President's Address.

PRESIDENT BRISTOL. The Constitution provides that the President shall make an annual address. I am a law-abiding citizen and intend to follow out my instructions, but as the Constitution does not say whether the address shall be formal or informal I shall take the liberty of making it informal. No formal address has been prepared.

I am very sorry that I cannot make an address that would please me and you as much as this Convention has pleased me and, I hope, has pleased you. The local Committee has been particularly efficient in providing us with everything that we could desire. I have had all confidence in Mr. Winsor as chairman, and I know he has selected a very able committee to assist him, and I am sure you all feel that we have been very well taken care of. In fact, I do not know where there has been a slip in all the arrangements.

It is logical to presume an address, if I had prepared one, should cover what has been accomplished during the past year. Our monthly meetings have been very well attended. I have not checked it up with the secretary,

but as we went along I was assured by him that we were having a big attendance, and it seemed so to me. We have had very good speakers, and as I remember them, the papers were prepared by outstanding men in the water-works field, such as Metcalf, Barbour, Hill, and Hazen, who, among others, favored us. Robert Spurr Weston was another man who favored us.

Financially we are slightly better off than we were last year. It looks from the reports, as I remember them, that we are quite a good deal better off in invested funds, but the reason is that we have put our funds at interest instead of carrying them in a checking account, and have drawn on advance payments this year more than we did last year.

There has been a slight decrease in membership, or had up to the first of September. I do not know how it would be now, but I should say that with the 25 additional members who have been received during this Convention we may be better off than we were last year.

We have not accomplished anything outstanding that I know of. There is one thing that we tried to put through, and that was to have the water departments pay the expenses of their representatives to conventions, and to encourage the members of water departments to come to the conventions.

I know that a letter which was sent out by the Committee has helped some in that respect, but I think we can do more along that line if we keep at it.

The only other thing I had in mind was to see if the salaries of the water-works men could not be bettered. There was a questionnaire sent out recently in that respect in an attempt to get at the real facts in reference to how much the salaries of different officials and laborers had increased. The questionnaires have come back to only a limited extent but I can give you what I have got so far in that respect, and what I get hereafter I will turn over to the next administration to do with as they please. It may be interesting to have me read that to you.

The salaries and wages in 1914, compared with 1926, are as follows: The registrars have increased 50 per cent.; chief engineers, 50 per cent.; pumping engineers, 60 per cent.; superintendents, 62 per cent.; assistant superintendents, 40 per cent.; clerks, 50 per cent.; meter readers, 70 per cent.; firemen, 70 per cent.; laborers, 108 per cent. This, you understand, is the increase over 1914.

There was included in this questionnaire the number of services in 1914 and 1926,— the meters, the consumption, revenue, expenses, and value of new work built and extensions in each of these years. The result is as follows: Services have increased 30 per cent.; meters, 58 per cent.; million gallons of water supplied, 28 per cent.; revenue, 48 per cent.; expenses, 46 per cent.; value of new work and extensions, 82 per cent. This is all for municipal works. The questionnaires have not been answered by enough private works to make any report.

There is one thing in connection with these increases which we ought to bear in mind, and that is that the work of superintendents and executives has increased, while there is no increase in the laborers' work. I think there would be a decrease if these answers were analyzed carefully.

In connection with the votes of thanks which have been passed, there are two other matters which should be mentioned. I wish to extend my personal thanks, and the thanks of the Association, to the persons who have prepared papers and presented them before us during the past year, both at the winter meetings and at this present Convention.

We have also been favored by some fine, sunny days during our Convention, for which we are all grateful to the weather man.

There are two suggestions which I have to offer. The first is regarding the question of how our headquarters functions since we have changed to the Affiliation. It is my opinion a committee ought to be appointed to look into that matter.

The second suggestion is that a committee ought to be appointed to consider how we can coöperate with the American Water Works Association.

That is all I have to say, except to thank everyone for the help he has given me in carrying on the administration. I have been very much pleased with this Convention and I hope you all have been I thank you. (*Applause.*)

FRANK E. WINSOR. Mr. President, I move that this Convention be dissolved.

(The motion was duly seconded and carried.)

(*Adjourned.*)

Annual Report of the Secretary.

Mr. President and Gentlemen of the New England Water Works Association,— The Secretary submits herewith the following report of the changes in membership during the past fiscal year, and the general condition of the Association.

The present membership is 785, constituted as follows: 8 Honorary, 682 Members, 2 Juniors, 87 Associates and 6 Corporate Members. The detailed changes are as follows:

MEMBERSHIP.

September 1, 1925.	Honorary Members		7		
	November, 1925	1			
	August, 1926	1			
			2		
	Withdrawals:				
	Died	1			8
September 1, 1925.	Total Members		654		
	Withdrawals:				
	Transferred to Honorary List	1			
	Resigned	20			
	Died	10	31	623	
	Elected:				
	September, 1925	6			
	October, 1925	1			
	November, 1925	4			
	December, 1925	5			
	February, 1926	2			
	March, 1926	6			
	May, 1926	5			
	June, 1926	4			
	August, 1926	3	36		
	Reinstated:				
	Resigned in 1911	1			
	Resigned in 1915	1			
	Resigned in 1917	1			
	Dropped in 1923–24	1			
	Dropped in 1924–25	19	23	59	682
September 1, 1925.	Total Juniors		2		
September 1, 1926.	Total Juniors				2
September 1, 1925.	Total Associates		84		
	Withdrawals:				
	Resigned	4	4	80	
	Elected:				
	September, 1925	1			
	January, 1926	1			
	June, 1926	1			
	August, 1926	1	4		

	Reinstated:				
	Resigned in 1917	1			
	Dropped in 1924–25	2	3	7	87
September 1, 1925.	Total Corporates		4		
	Elected:				
	March, 1926	1			
	May, 1926	1	2		6
September 1, 1926.	Total Membership				785
September 1, 1925.	Total Membership				751
	Net gain				34

Members Elected from September 1, 1925, to September 1, 1926.

September 8 to 11, 1925. W. C. Campbell, R. B. Chalmers, H. R. Leach, Hermann Rosentreter, C. C. West, S. G. Wylie. (6)
October 3, 1925. Homer O. Blair. (1)
November 10, 1925. W. S. MacFayden, C. E. Fuller, H. U. Fuller, Abel Wolman. (4)
December 8, 1925. A. P. Gallant, F. A. Gay, F. T. Hook, E. P. Kable, Kenneth Shibley. (5)
February 9, 1926. F. R. Ackley, H. M. Beverly, P. E. Bond, G. E. Gomley, A. B. Graves, W. V. Howes. (6)
May, 3 1926. Prof. Manifredi de Horatiis, Sol Pincus, Frederick Sheppers, C. L. Bogert, Dr. L. G. Bunker. (5)
June 22, 1926. H. L. Field, A. V. Ruggles, C. R. Wood, H. W. Macomber. (4)
August 14, 1926. G. E. Barnes, Charles Haydock, J. E. Moore. (3)
Reinstated:
Resigned in 1911, A. S. Merrill. (1)
Resigned in 1915, J. S. Sanborn. (1)
Resigned in 1917, H. J. Skinner. (1)
Dropped in 1923–24, A. F. Hart. (1)
Dropped in 1924–25, G. A. Adams, George F. Ashton, R. K. Blanchard, W. F. Codd, E. R. Conant, H. F. Cox, H. C. Crowell, F. J. Dixon, A. B. Farnham, DaytonW. Frederick, H. B. Keeler, Jr., U. S. Lambert, T. W. Lesage, H. P. T. Matt, H. L. Newhall, W. G. Newhall, Alexander Potter, W. M. Scott, F. N. Strickland. (19)

Honorary Members.

November 10, 1925. Leonard Metcalf. (1)
August 18, 1926. Clemens Herschel. (1)

Corporate Members.

March, 1926. Chicopee (Mass.) Board of Water Comrs. (1)
May, 1926. Berlin (N. H.) Water Works. (1)

Associate Members.

September 8 to 11, 1925. Hydraulic Development Co. (1)
January 12, 1926. B. Nicoll & Company, Inc. (1)
June 22, 1926. Sumner & Dunbar. (1)
August 14, 1926. Joseph J. Monahan. (1)
Reinstated:
Dropped in 1924–25, Ashton Valve Co., W. Guy Classon. (2)
Resigned in 1917, H. W. Clark. (1)

Honorary Member.

Died, Leonard Metcalf.

Members.

Died: H. S. Charron, W. T. Dotten, D. A. Hartwell, C. A. Hatch, C. H. Nettleton, A. F. Sickman, A. D. Theriault, D. N. Tower, F. H. White, G. E. Winslow. (10)

Resigned: R. E. Andrews, E. B. Bain, J. K. Barker, E. R. Conant, G. S. Deming, Philip DeWolf, James Fitzgerald, A. D. Flinn, J. W. Hill, C. S. Howe, W. D. Hubbard, O. N. Mayhew, W. A. Megraw, F. B. Nelson, Marcel Pequegnat, H. E. Reed, F. H. Taber, L. E. Thayer, C. L. Ward, G. C. White. (20)

Associate Members.

Resigned: Birch Mfg. Co., W. Guy Classon, General Chemical Co., Multiplex Manufacturing Company. (4)

Receipts for Fiscal Year, September 1, 1925, to September 1, 1926.

Entrance Fees			$165.00
Annual Dues:			
Members	$3 676.62		
Juniors	6.00		
Associates	1 600.00		
Corporates	30.00		
		$5 312.62	
Fractional Dues:			
Members	$73.00		
Associates	20.00		
Corporates	10.00		
		103.00	
Back Dues		181.00	
Prepaid Dues (1926–27)			
Members	$830.50		
Associates	480.00		
		1 310.50	
Total Dues			$6 907.12
Advertisements			3 439.00
Subscriptions			442.01
JOURNALS Sold			85.75
Sundries			891.07
Total receipts			$11 929.95
There is due the Association:			
Advertisements		$754.00	
JOURNALS		10.50	
Subscriptions		8.00	
		$772.50	772.50
TOTAL			$12 702.45

Respectfully submitted,

FRANK J. GIFFORD, *Secretary.*

Annual Report of the Treasurer.

September 1, 1925, to August 31, 1926.

The President and Members of the New England Water Works Association:

I herewith submit my report as treasurer for the year ending August 31, 1926.

Receipts.

September 1, 1925 — Cash on hand			$3 148.14
Initiation fees	$ 165.00		
Dues	6 907.12	$7 072.12	
Interest and dividends		557.16	
Journal:			
Advertisements	3,439.00		
Subscriptions	442.01		
Sale of Journals	85.75		
Sale of reprints	152.23	4 118.99	
Miscellaneous:			
Certificates of membership	18.50		
Meter sheets	1.63		
Membership lists	4.00		
Sale of buttons	.75		
Standard specifications	7.00		
Surplus dinner tickets	113.75		
B. S. C. E. acct. June outing	36.05	181.68	
Total receipts			11 929.95
			$15 078.09

Expenditures.

Journal:			
Advertising agent's salary	$100.00		
Advertising agent's commission	34.80		
Editor's salary	300.00		
Editor's expense	9.00		
Plates	494.87		
Printing	4 501.95		
Reporting	296.80		
Reprints	643.02		
Stationery and postage	134.65		
Sundries	9.53	$6 524.62	
Office:			
Affiliated Technical Societies	$1 950.00		
Printing, stationery and postage	461.02		
Secretary's salary	200.00		
Secretary's expense	171.52		
Sundries	11.30	2 793.84	
Meetings and Committees:			
Dinners for guests	$3.00		
Badges	8.30		
Printing, stationery and postage	388.06		
Stereopticon	40.00		
Sundries	28.15	467.51	

Miscellaneous:			
Certificates of membership	7.20		
Exchange	1.00		
Treasurer's salary and bond	62.50		
Sundries	45.53	116.23	
Total expenditures			$9 902.20
Transfer to Invested Funds			5 000.00
			$14 902.20
August 31, 1926 — Cash on hand			175.89
			$15 078.09

Invested Funds.

Invested funds September 1, 1925	$8 622.43
Paid to invested funds	5 000.00
Interest on bonds	80.00
Interest on deposit	70.87
Interest on savings bank deposits	406.29
	$14 179.59
Interest paid over to the Association	$557.16
Invested funds August 31, 1926	13 622.43
	$14 179.59

As the Association had accumulated a considerable surplus, the Executive Committee deemed it wise to transfer to the Invested Funds, such an amount as was not needed to take care of the current expenses. I have therefore during the year deposited in savings banks the sum of $5 000.00.

The Finance Committee for the fiscal year ending August 31, 1926, recommended a budget of $10 600.00.

There has been expended during the year $9 902.20, leaving an unexpended balance of $697.80. The details are as follows:

	Journal.	*Office.*	*Meetings.*	*Miscellaneous.*
Appropriation	$6 900.00	$2 800.00	$700.00	$200.00
Expended	6 524.62	2 793.84	467.51	116.23
Balance	$375.38	$6.16	$232.49	$83.77

Respectfully submitted,

ALBERT L. SAWYER, *Treasurer.*

TREASURER'S REPORT.

STATEMENT OF RECEIPTS AND EXPENDITURES.

Receipts.		*Expenditures.*	
Cash on hand September 1, 1925	$3 148.14	Bills paid as per vouchers	$9 902.20
Interest on bonds and deposits	557.16	Transfer to Investment Funds	5 000.00
Received from Secretary	11 372.79	Cash on hand August 31, 1926	175.89
	$15 078.09		$15 078.09

ASSETS AND LIABILITIES.

Assets.			*Liabilities.*	
Cash in banks as per list		$11 983.32	Surplus	$14 570.82
Old Colony Trust Co.	$175.89			
Farmers and Mechanics Savings Bank Framingham	2 068.46			
Franklin Savings Bank	2 000.00			
Home Savings Bank	1 011.25			
Mechanics Savings Bank	261.19			
Peoples Savings Bank	1 466.53			
Haverhill Savings Bank	2 000.00			
City Five Cents Savings Bank	1 500.00			
Pentucket Savings Bank	1 500.00			
Bonds Nos. 2642 and 2644 Lake Shore & Michigan So. R.R. 4's due May 1, 1931	1 815.00			
Accounts Receivable	772.50			
Advertisements	754.00			
JOURNALS	10.50			
Subscriptions	8.00			
		$14 570.82		$14 570.82

Annual Report of the Editor.

To the New England Water Works Association: The Editor submits herewith the following report for the year ending August 31, 1926.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received or disbursed.

Table 1 is a statement of the material published.

Table 2 gives the receipts and expenditures for the year.

Table 3 is a comparison of the JOURNAL for the past year with preceding years.

Size. The four issues contained 761 pages, of which 523 were text.

Cost. The gross cost of the JOURNAL was $6 524.62, equivalent to $8.42 per member, and, the net cost was $2 040.28, equivalent to $2.64 per member.

Reprints. Fifty reprints of each paper have been furnished to the author where desired.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	785
Subscribers	108
Exchanges	13
Total	906

(JOURNALS have been sent to all subscribers.)

Respectfully submitted,

JOHN P. WENTWORTH, *Editor.*

EDITOR'S REPORT.

TABLE 1.

STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1925, AND MARCH AND JUNE, 1926, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

Date.	Pages of								
	Papers.	Proceedings.	Total Text.	Index.	Advertisements.	Cover and Contents.	Insert Plates.	Total.	Total Cuts.
September, 1925....	87	19	106	0	48	5	0	159	6
December, 1925....	171	2	173	6	48	5	10	242	59
March, 1926.....	108	7	115	0	51	5	3	174	18
June, 1926.....	129	0	129	0	52	5	0	186	30
Total.....	495	28	523	6	199	20	13	761	113

TABLE 2.

RECEIPTS AND EXPENDITURES ON ACCOUNT OF SEPTEMBER AND DECEMBER, 1925, AND MARCH AND JUNE, 1926, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

Receipts.		*Expenditures.*	
Advertisements	$3 927.00	Advertising agent's salary and commissions	$134.80
Sale of JOURNALS	68.50	Plates	494.87
Reprints	78.83	Printing	4 501.95
Subscriptions	410.01	Reporting	296.80
	$4 484.34	Mailing and postage	134.65
Net cost of JOURNAL	2 040.28	Editor's salary	300.00
		Editor's incidentals	9.00
		Reprints	643.02
		Sundries	9.53
	$6 524.62		$6 524.62

EDITOR'S REPORT.

TABLE 3.

COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.

	Vol. XXIX. 1915.	Vol. XXX. 1916.	Vol. XXXII. 1918.	Vol. XXXIII. 1919.	Vol. XXXIV. 1920.	Vol. XXXV. 1921.	Vol. XXXVI. 1922.	Fiscal Year Ending Aug. 31, 1924. 4 issues.	Fiscal Year Ending Aug. 31, 1925. 4 issues.	Fiscal Year Ending Aug. 31, 1926. 4 issues.
Average edition (copies printed)	1 325	1 500	1 388	1 200	1 130	1 150	1 100	1 100	1 100	1 100
Average membership	904	1 002	954	902	885	864	826	764	755	775
Circulation at end of year	1 079	1 155	1 010	1 002	970	929	929	880	873	906
Pages of text	596	538	398	566	359	399	618	404	421	523
Pages of text per 1 000 members	659	538	417	627	406	462	748	529	558	675
Total pages, all kinds	776	707	557	726	520	560	801	611	644	761
Total pages per 1 000 members	859	707	584	805	588	648	970	800	853	982
GROSS COST:										
Total	$4 243.35	$3 386.63	$3 115.00	$4 967.99	$5 011.03	$5 381.84	$6 354.10	$4 783.60	$5 272.91	$6 524.62
Per page	5.47	4.79	5.59	6.84	9.64	9.61	7.93	7.83	8.19	8.57
Per member	4.68	3.38	3.26	5.51	5.66	6.23	7.69	6.26	6.98	8.42
Per member per 1 000 pages	6.02	4.79	5.85	7.59	10.88	11.12	9.60	10.25	10.84	11.07
Per member per 1 000 pages text	7.85	6.30	8.19	9.74	15.77	15.61	12.47	15.50	16.58	16.10
NET COST:										
Total	$1 091.09	$1 171.98	$694.54	$2 675.04	$1 722.14	$1 869.85	$2 434.26	$561.51	$943.40	$2 040.28
Per page	2.70	1.65	1.25	3.68	3.31	3.34	3.04	0.92	1.46	2.68
Per member	2.32	1.17	.73	2.97	1.95	2.16	2.95	0.74	1.25	2.64
Per member per 1 000 pages	2.98	1 65	1.31	4.09	3.75	3.87	3.68	1.20	1.94	3.47
Per member per 1 000 pages text	3.88	2.17	1.83	5.25	5.43	5.43	4.77	1.82	2.97	5.05

Report of Finance Committee.

Executive Committee,
New England Water Works Association.
Gentlemen:

The Finance Committee submits the following budget for the fiscal year ending August 21, 1927:

Journal printing	$5 000
Journal miscellaneous	2 000
Office	2 600
Meetings and Committees	700
Miscellaneous	200
Total	$10 500

For the fiscal year just passed, the Treasurer has included 1926–27 dues received prior to September 1 and amounting to $1 310.50 as receipts for the year 1925–26, which amount has been transferred to invested funds. In making an estimate of the receipts available for the coming year, we have assumed that the same policy will be continued, as otherwise a considerable reduction in the budget will be necessary to keep the expenditures within the receipts.

The amount to be paid to the Affiliated Technical Societies of Boston is $2 000, which is an increase of $50 from the last fiscal year.

A reduction of $200 is assumed in office expenses as the printing of the Constitution and List of Members will be omitted during the coming year.

The budget allows $5 000 for printing the Journal, which is about $500 in excess of the cost during the past year, as it is hoped that this publication may be still further expanded; $2 000 is allowed for Journal Miscellaneous, making a total of $7 000.

The surplus which has been accumulating for the past few years has been transferred to invested funds in the amount of $5 000.

Respectfully submitted,

GEORGE A. SAMPSON,
RICHARD H. ELLIS,
DWIGHT L. AGNEW,

Finance Committee.

September 13, 1926.

REPORT OF COMMITTEE ON A SYSTEM OF SANITARY SCORING OF WATER SUPPLIES.

Your committee on "A System of Sanitary Scoring of Water Supplies," begs to submit the following progress report.

At the annual convention of the Association in 1925 the chairman of this committee presented a paper upon "A Score System for Grading Water Supplies according to Sanitary Conditions." As a result of this paper and the discussion which followed, it was voted that the Executive Committee be authorized to appoint a committee upon the subject. Such a committee was subsequently appointed.

No formal meeting of the committee has been held but business matters have been taken up by correspondence and also at informal meetings of the Boston members.

Immediately after its appointment the committee undertook the following program:

1. It adopted tentatively the score system presented by its chairman as a starting-point.

2. Reprints of the paper describing this system were sent to various engineering divisions of State Health Departments and to other interested water-works men, together with a letter requesting opinions, criticisms, and suggestions.

3. Reprints of the paper were also sent to some 39 water-works superintendents in New England with the request that each score his own supply according to the method outlined in the reprint.

4. Other systems of scoring water supplies were collected and compared.

The responses to the requests for criticisms and suggestions were disappointingly few and of the 39 water-works superintendents who were asked to score their own supplies only two answered.

Such suggestions and criticisms as were received dealt mainly with the details of the system and were not directed against the major principle involved. In fact, it seems to be conceded that some scheme for scoring the sanitary quality of water supplies may be worked out that would be as satisfactory as those used for scoring milk supplies or fire hazards.

A study of other proposed score systems, particularly one advanced by a Sub-Committee on Field Survey of the United States Public Health Service Advisory Committee on Official Water Standards in 1923, indicates that the system adopted tentatively by your committee promises to be more simple of application and probably fully as accurate as any yet proposed.

The committee members themselves have attempted to score several supplies and as a result of their efforts, as well as of the suggestions from others, have modified in a number of particulars the system presented last year. The modified system is given in the following outline.

OUTLINE OF SCORE SYSTEM.

(Modified as of September, 1926.)

SURFACE SUPPLIES.

(Main Group.)

I. *Pollution Hazards:*	
Score for no hazard	60
Hazards connected with Sources of Supply:	
1. Population on watershed (p = population per sq. mile of watershed):	
a. Contributing indirect pollution	$-2\sqrt{P}$
b. Contributing direct pollution (sewage)	$-8\sqrt{P}$
c. Where sewage is diverted from watershed	$-2\sqrt{P}$
2. Highways and railroads (per linear mile per sq. mile of watershed)	−1
3. Lumbering, labor camps, hunting, etc.:	
a. Lumbering, labor camps, etc.	−2
b. Hunting, picnicking, etc.	−1
4. Animal pollution:	
a. Direct	−2
b. Indirect	−1
5. Industrial wastes	−5
6. Leaky intake, suction main or gravity main passing through sewage-polluted water	−25
Hazards connected with Storage and Distribution of Supply:	
7. Fishing, boating, ice-cutting, bathing, etc., on reservoirs:	
a. Fishing and boating	−2
b. Ice-Cutting:	
Ice house at reservoir	−2
Ice house away from reservoirs	−1
c. Bathing	−5
8. Accessible distribution reservoirs:	
a. Open and unprotected	−5
b. Open but protected by locked fence, etc.	−2
9. Inadequate protection against polluted water leaking into pure-water reservoirs, e. g., double-storage tanks, one part for safe and other for unsafe water; leaky raw water conduits passing through clear-water basins, etc.	−5
10. Cross-connections with polluted supplies:	
a. Single or no check valve	−15
b. Double check, F. M. type, regularly inspected	−10
11. Dual water-supply systems, one from a safe source and the other, for emergency use, from a sewage-polluted source	−10
12. Inadequate pressure and storage	−10
II. *Protective Measures:*	
Total score not to exceed	30
1. Sewage and industrial wastes treatment, divide score for direct-pollution hazard and industrial wastes sewage according to extent of treatment, as follows:	
a. Sedimentation, divide by 2.	
b. Complete treatment without disinfection, divide by 3.	
c. Complete treatment with disinfection, divide by 4.	
2. Proper sanitary regulation, patrol, and enforcement	4
3. Ownership of watershed, 100 %	5
(For less than 100%, pro-rate according to area owned.)	
4. Storage (minimum):	
a. One month or more	10

b. Two weeks	5
5. Water Purification:	
a. Chlorination	10
b. Pressure mechanical filters:	
With coagulation basin	10
Without coagulation basin	5
c. Gravity mechanical filters	15
d. Slow sand filters	15
e. Copper sulphate treatment, aeration, etc., for algae	5
(For combinations of the above purification methods, add individual scores, total credited not to exceed 30.)	
Penalties for Failure or Inadequacy of Protective Measures.	
1. Improper operation of sewage and industrial wastes treatment plants — allow no credit.	
2. Lax enforcement of sanitary regulations, improper or inadequate regulations, irregular patrol or none	−2 to −4
3. Short circuits in storage reservoirs	−5
4. Improper operation of purification plants: (not to exceed −15):	
a. Inadequate dosage of chlorine	−10
b. Intermittent operation of chlorination apparatus, absence of duplicate equipment, etc.	−5
c. No coagulant with mechanical filters	−10
d. Exhaustion of chemicals or chemicals of poor quality	−5
e. Filters in poor condition	−5
f. Combustible buildings housing essential equipment	−5
5. No or inadequate laboratory control of water quality	−5
III. *Quality Conditions:*	
Total score not to exceed	30
Turbidity:	
Clear	2
0 to 5 p.p.m.	1
Over 5 p.p.m.	0
Color:	
Colorless	2
0 to 10 p.p.m.	1
Over 10 p.p.m.	0
Odor:	
None	2
Penalty for bad odors up to	−5
Taste:	
None	2
Penalty for bad taste up to	−5
Hardness:	
Under 50 p.p.m.	1
Corrosiveness:	
None	1
Iron and manganese:	
Less than 0.5 p.p.m.	1
Penalty for iron in excess of 1 p.p.m.	−3
Total bacterial counts on agar at 37° C.—24 hrs.:	
Less than 100 per c.c.	5
Over 100 per c.c.	0

B. coli type:

Absent in 100% of 10 c.c. inoculations 20

(Present in part of 10 c.c. inoculations, pro-rate according to per cent. of samples positive.)

SURFACE SUPPLIES.

(Sub-group: Great Lakes, Mississippi and St. Lawrence rivers.)

I. Pollution Hazards:

Score for no hazard 60

Population within two weeks' time of flow above intake in case of rivers, or within 30 miles of intake in case of Great Lakes (p = population 1 000):

a. Contributing indirect pollution ..... $-2\sqrt{p}$

b. Contributing direct pollution ..... $-8\sqrt{p}$

(Other pollution hazards score, where applicable, the same as for main group.)

II. *Protective Measures:*

Same as for main group.

III. *Quality Conditions:*

Same as for main group.

GROUND WATER SUPPLIES.

(Main group: depth less than 200 ft.)

I. *Pollution Hazards:*

Score for no hazard 60

1. Population (p = population):

a. Between radius of 1 000 ft. and 3 000 ft. ..... $-\frac{\sqrt{p}}{30}$

b. Between radius of 500 ft. and 1 000 ft. ..... $-\frac{3\sqrt{p}}{3}$

c. Within radius of 500 ft. ..... $-8\sqrt{p}$

2. Sewers, cesspools, etc., within 500 ft. ..... −10
3. Improperly protected top ..... −5
4. Leaky casings ..... −5
5. Connections with polluted surface water ..... −10
6. Flooding of vicinity by sewage-polluted surface water ..... −5
7. Distribution hazards:

The same as for surface supplies.

II. *Protective Measures:*

Total score not to exceed 30

1. Depth and kind of strata penetrated:

Sand under 20 ft. in depth	5
Sand over 20 ft. in depth	15
Sand and gravel under 20 ft. in depth	3
Sand and gravel over 20 ft. in depth	10
Seamy rock and limestone	0
Impervious layer above water-bearing stratum	10

2. Purification methods:

Credits and penalties the same as for surface supplies.

III. *Quality Condition:*

The same as for surface supplies.

GROUND WATER SUPPLIES.
(Sub-group; depth more than 200 ft.)

I. *Pollution Hazards:*

Score for no hazard 50

1. Population (p = population):

a. Within a radius of 1 000 ft. ..... $-3\sqrt{\frac{p}{3}}$

(Other pollution hazards the same as for main group.)

II. *Protective Measures:*

Total score not to exceed 20

1. Overlying soil:

Same as for main group.

2. Purification methods:

Credits and penalties the same as for surface supplies.

III. *Quality Condition:*

The same as for surface supplies.

Any system of scoring must be applied to a large number of cases in order to secure an approach to a unanimous opinion as to the relative value of the various factors involved. It is the earnest desire of the committee that a large membership of the Association apply the modified score system to the supplies which they may have in charge. In view of the fact that so few independent scores have been submitted, the committee does not feel that the system which it adopted tentatively is as yet in form to be definitely accepted or rejected.

Your committee believes the subject worthy of further study and recommends that it be continued. Your committee requests that every superintendent member score his own water supply and submit the details of the scoring to the committee.

Respectfully submitted,

E. SHERMAN CHASE, *Chairman,*
J. FREDERICK JACKSON,
ARTHUR D. WESTON,

Committee on a System of Sanitary Scoring of Water Supplies.

September 14, 1926.

LEONARD METCALF — A MEMOIR.

(Died January 29, 1926.)

Leonard Metcalf was born on August 26, 1870, in Galveston, Texas, the child of Joseph Houghton and Emma Augusta (Leonard) Metcalf. His home for the greater part of his life was in Concord, Mass.

He was graduated in 1892 from the Massachusetts Institute of Technology. After three years' employment with Wheeler and Parks, Civil Engineers, Boston, and two years as Professor of Mathematics and Engineering at the Massachusetts Agricultural College, he established an office in Boston in 1897, and began the practice of his profession in his own name. Ten years later he joined with Harrison P. Eddy to form the partnership of Metcalf & Eddy.

Mr. Metcalf's most outstanding accomplishments were in the field of municipal water works, in the design and construction of various systems, in the management of plants, and particularly in valuation and rate-making for public utilities in which he became prominent among that small group of engineers who, by honesty, sound judgment, and technical equipment, have become recognized as experts in this branch of the profession.

His field of practice covered the entire country, and included such clients as the Boston Finance Commission; Dayton, Ohio; Denver Union Water Company; Des Moines Water Company; Indianapolis Water Company; Passaic Consolidated Water Company; Pawtucket, R. I.; Portland Water District, Me.; San Antonio Water Supply Company; Spring Valley Water Company (San Francisco); Consolidated Water Company of Utica; United Fruit Company; Tampa Water Company; and many other cities and corporations. During 1925 he was consulting engineer of the Metropolitan Water Supply Investigating Commission of Massachusetts.

His writings, published in the Journals of the American and the New England Water Works Associations, the Transactions of the American Society of Civil Engineers, and in the recently issued Manual of American Water Works Practice, bear witness to the logic and accuracy of his conclusions, and of his desire to make such material available to the profession rather than to hold it for his personal use.

Among the most important of the papers contributed by Mr. Metcalf to technical societies are the following:

For the American Society of Civil Engineers: "The Antecedents of the Septic Tank"; "The Groined Arch as a Covering for Reservoirs and Sand Filters"; "Water Works Valuation and Fair Rates in the Light of the

Maine Supreme Court Decision"; "The Going Value of Water Works" (with John W. Alvord); "Final Report of the Special Committee to Formulate Principles and Methods for the Valuation of Railroad Property and Other Public Utilities" (Mr. Metcalf was secretary of the committee).

For the American Water Works Association: parts of several chapters in the "Manual of American Water Works Practice," 1925; "Some Fundamental Considerations in the Determination of a Reasonable Return for Public Fire Hydrant Service" (with Kuichling and Hawley); "Some Practical Checks on Water Works Depreciation Estimates"; "Experiences with Ice in Standpipes"; "The War Burdens of Water Works"; "The Improved Financial Condition of Water Works."

For the New England Water Works Association: "Depreciation in Water Works"; "Echo Lake Dam at Milford"; "Wrought Iron Cement-Lined Pipe"; "Data on Awards for Water and Water Power Diversion" (report of a committee of which Mr. Metcalf was secretary).

He was a joint author with Harrison P. Eddy of the well-known three-volume treatise on "American Sewerage Practice," and of the one-volume abridged edition, "Sewerage and Sewage Disposal," which is now used in upwards of sixty universities and colleges in this country.

Mr. Metcalf was a member of many professional societies, most of which he had served on various committees, and as an officer. Among these are the American Society of Civil Engineers, in which he had been Director and Vice-President; the American Society of Mechanical Engineers; the Boston Society of Civil Engineers, of which he was President in 1919; the American Water Works Association, President 1916-17; New England Water Works Association, President, 1915, and Honorary Member.

Unselfishly and freely he gave of his time and means to committees and other work of these societies, and his services to his profession will long be remembered by those who were fortunate enough to be associated with him.

Mr. Metcalf's interest in the Massachusetts Institute of Technology was unceasing. He was President of the Alumni Association in 1920, and was a term member of the Corporation of the Institute at the time of his death. That his ability and character were recognized by his Alma Mater is well evidenced by the fact that subsequent to the death of Dr. MacLaurin the Executive Committee of the Corporation asked him to accept the presidency of the Institute.

For several years he served the town of Concord as a trustee of the public library, and since 1915 as a member of the Board of Water and Sewer Commissioners, of which he was chairman from 1917.

On the declaration of war in 1917 Mr. Metcalf was made a member of the sub-committee on Emergency Construction of Buildings and Engineering Structures, under the National Council of Defense, which assisted General Littell in creating the Construction Division, in selecting personnel, developing forms of contracts, providing lists of contractors, fixing canton-

ment sites, and awarding contracts. Only those who are intimately acquainted with the subsequent work of the Construction Division can fully measure the value of the services rendered by these civilian members of the Emergency Council in determining policies and in giving to the military authorities the moral backing necessary in putting these policies promptly into effect. In this unspectacular but important work Mr. Metcalf tirelessly and effectively did his full share.

Mr. Metcalf was a member of the Union Club of Boston, the Engineers' Clubs of Boston and New York, the University Club of Chicago, and the Social Circle of Concord. He enjoyed art and good literature; he was fond of nature and spent much time in the mountains of California and the Colorado Rockies, where he had his vacation home.

Perhaps the most marked and underlying characteristic of Leonard Metcalf was his loyalty and devotion to his family — his mother throughout her life, his two sisters, and more distant relatives. He was not married.

His standard of professional ethics was high; he never repeated anything derogatory to another engineer; he was keenly interested in the welfare of his professional associates and his sympathy and generosity were outstanding. He practised engineering as a profession and counselled thoroughness, accuracy, and always that the interests of the client must be the controlling factor. His sympathy, enthusiasm, and optimism — tempered by sound judgment — were a source of inspiration to all those in contact with him. He was an indomitable worker. His keen intellect, quickness of thought and action, and his will to work, — all contributed to a productiveness which was always a source of wonder to his associates.

All his life he "faced the facts," and when told that, beyond question, his malady was fatal and his time limited, he calmly adapted himself to the inevitable and continued his work with full power of concentration and enthusiasm almost to the end. Only as weakened by his illness did he give ground, step by step, to approaching death, and always in full control of his mind and spirit.

> "Fear death? — to feel the fog in my throat,
> The mist in my face . . .
> I was ever a fighter, so — one fight more,
> The best and the last!
> I would hate that death bandaged my eyes, and forbore,
> And bade me creep past,
> So let me taste the whole of it, fare like my peers,
> The heroes of old."

In professional attainments, in character, in capacity for friendship, in loyalty and helpfulness to others, the life of Leonard Metcalf may well serve as an example to his profession.

ROBERT S. WESTON,
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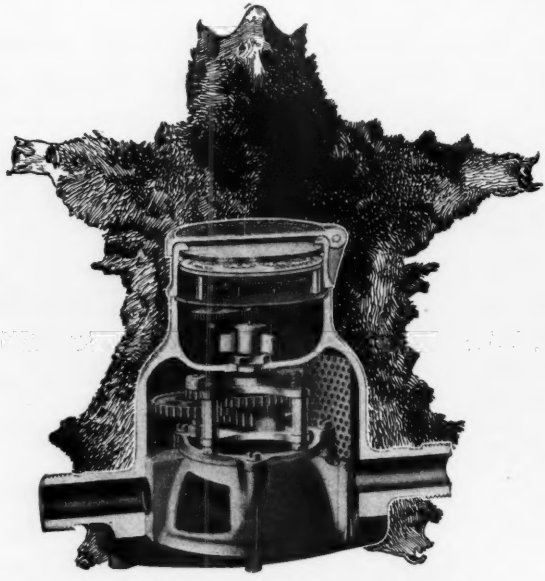
Telephone, Richmond 1200



Does a Thick Tin Skin *Protect* a Water Meter?

THE experience of thousands of users of Hersey Domestic Water Meters proves that the answer is Yes — emphatically, YES.

Tinning protects the meter against corrosion. It adds years of life to meter service. It prevents premature decay. When accumulations occur they are much more easily removed from a tinned surface than from an untinned surface. Repairs are much less frequent and the work is much more easily accomplished.

Dipping adds a much thicker coat of metal than any other process. Therefore Hersey Meters are dip tinned. It is slow and expensive, but it gives the best results. Dip tinning is an exclusive Hersey process.

The BALANCED DISC PISTON which enables Hersey Meters to run for years without loss of registration is another exclusive HERSEY feature found in no other meter.

If performance determines your purchase of water meters, then you will want these accurate, dependable revenue computors to work for you.

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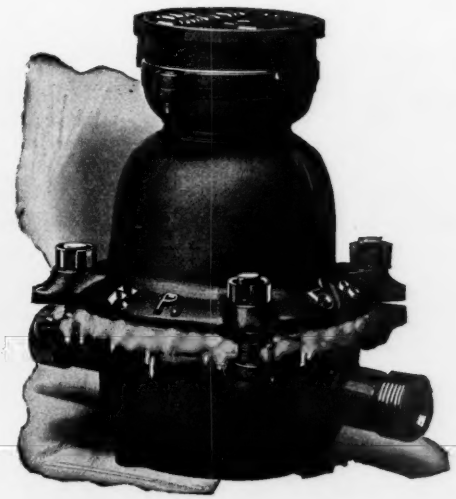

FROZEN!—but not damaged

Here is an actual photograph of a LAMBERT Frost-proof Meter which has been frozen to an extent that would put the ordinary meter completely out of commission.

This is made possible by a patented, non-corrosive yielding bolt device which allows the upper and lower casing, disc chamber and gear train to part without damaging the meter in any way. Five minutes' labor the only repair cost.

The expense and annoyance from frozen water meters can be eliminated for all time through the installation of the LAMBERT Frost-proof.

It has been proved that the LAMBERT is the easiest water meter to take apart and put together again as well as the simplest, most reliable and accurate.

If you are interested in other types of meters, we make one for every requirement.

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SALES OFFICE: 50 EAST 42nd STREET, NEW YORK CITY, N. Y.

LAMBERT FROST-PROOF METERS

3,000,000+ NEPTUNE TRIDENT
METERS IN USE IN THE UNITED STATES

One of the Reasons···

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FOR these 3,000,000 plus—Trident meters now in use in the United States, is the fact that a Neptune Trident Meter need never become obsolete.

Trident interchangeable parts have reduced to a minimum, the upkeep on these standard meters of accuracy.

Every improvement—as it is made in Trident Meter construction—may be applied to meters previously in service making them just as efficient and modern as if they were installed today.

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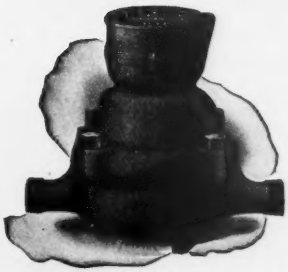
PITTSBURGH METER CO.

The ARCTIC — A frost-bottom meter, especially designed for cold sections of the country.

ARCTIC



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The TROPIC — An all-bronze Water Meter, with connection spuds attached to the lower case. Particularly designed for warm sections of the country.

These two meters embody exactly the same mechanical features, the only difference being the changes necessary to provide a frost breaking feature in the Arctic.

Either of these meters will be equipped with a COMPLETELY ENCLOSED intermediate train RUNNING IN OIL, if desired.

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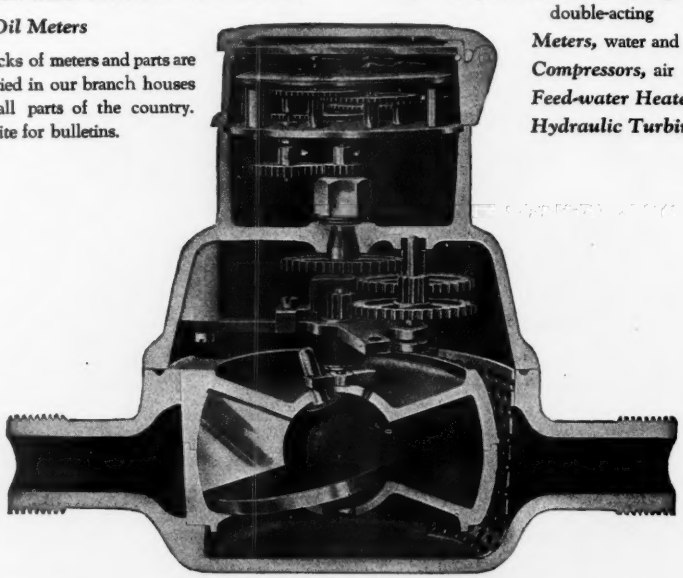

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The History of VENTURI No. 2

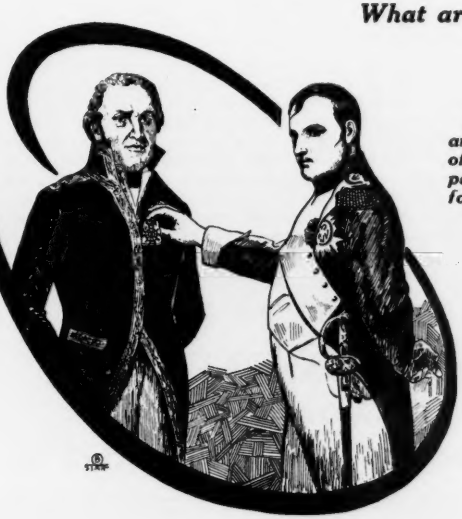
Back in 1797 Giovanni Batista Venturi, Italian engineer, University professor and acknowledged authority on hydraulics, announced that

fluids under pressure, in passing through converging pipes, gain speed and lose head, and vice versa for diverging pipes.

During a stay of a year and a half in Paris, Venturi labored so constructively and conspicuously that Napoleon made him a professor at the military school of Modena and finally appointed him a Chevalier of the Legion of Honor.

Today the same principle in perfected "Venturi Meters" is being used in thousands of towns and cities in the maintenance and conservation of the water supply, in filtration and in sewage disposal.

What are your problems?



Instructive bulletins and the co-operation of our engineering department are yours for the asking.

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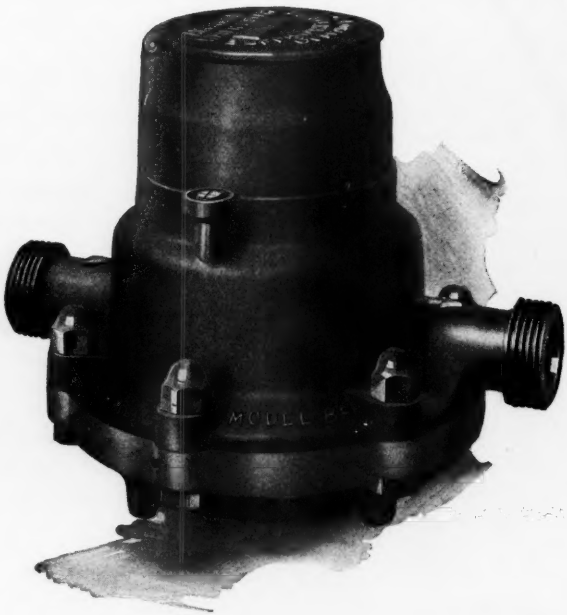
AMERICAN AND NIAGARA
WATER METERS



American and Niagara meters are made in solid casing types and frost bottom types. The illustration above shows a $^{5}/_{8}$" x $^{3}/_{4}$" meter of the frost bottom type. Those meters having bronze outside casings are known as Americans and those having galvanized cast-iron outside casings are Niagaras. The works in all the different casings are of one best model and interchangeable. The registers may be either round reading or straight reading and may indicate cubic feet, U. S. gallons, imperial gallons or litres. All Niagara and American meters are tested and adjusted according to the requirements of the Standard Specifications for water meters adopted by the New England Water Works Association and the American Water Works Association.

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ESTABLISHED 1892

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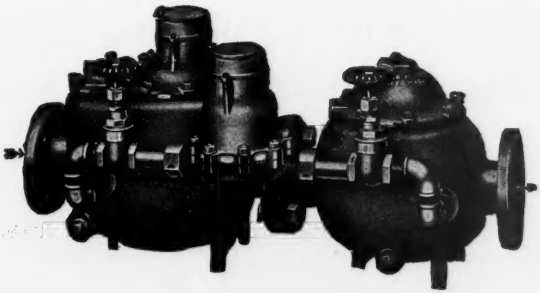

The New Nilo

The new improved **Nilo Compound Meter** now comes equipped with a bronze body. This is a valuable addition to meter service for it eliminates the danger of corrosion and filling up due to the collecting of corrosive matter. Bronze being stronger than iron the gross weight of the meter is less, making it easier to transport, handle and install.

It also has two gate valves which allow the removal of the by-pass meter for cleaning or repairing without shutting off the line.

The controlling valve mechanism of the new **Nilo Compound Meter** is self contained and easily detached from the main body casings.

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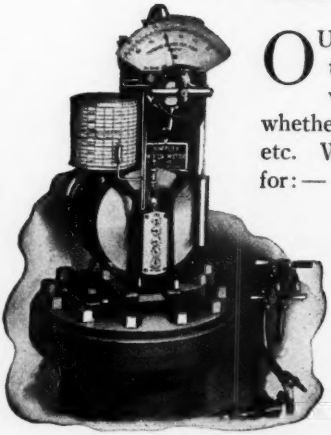

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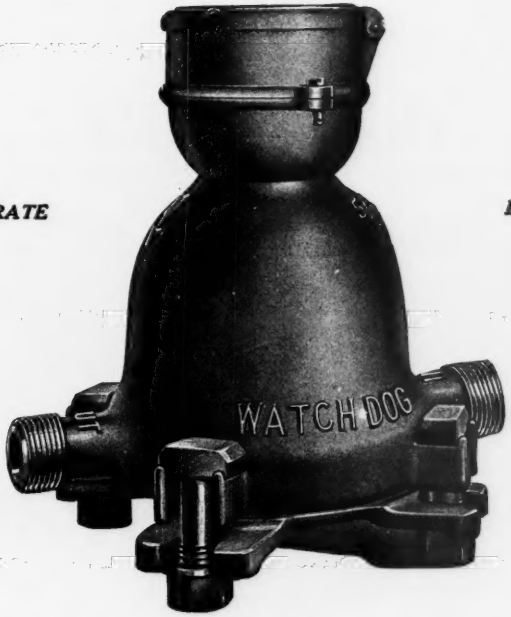

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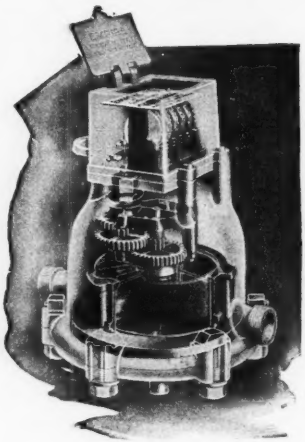

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Fully descriptive EMPIRE circular gladly sent on request.

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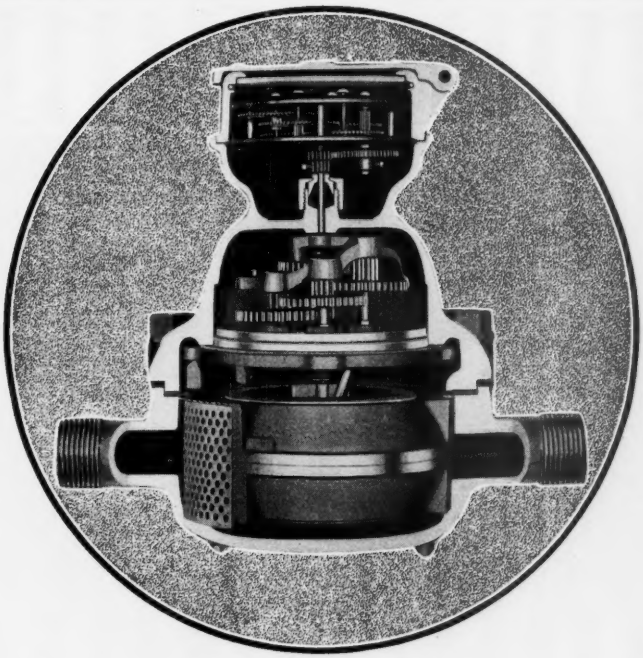

Badgers Lead!

City after city is standardizing on Badger Meters. But only after careful study — careful test — careful comparison of maintenance costs.

This ever-increasing popularity is gratifying — but not surprising. For Badgers are built up to the highest standards known to meter manufacturers — manufacturers who build nothing else.

Take for example the Model "SC" shown above — it is different from ordinary meters of this type and size. It is **designed** for a certain service. Its sturdy construction — heavy bronze housing — a housing that will not distort — in every particular, a **lifetime meter.**

All Badger types embody advantages of design and construction that permit them to stand out prominently in the general meter field. They are built to give long years of service — accurate registration — lowest maintenance cost — practical design — simplest construction — and are **built to last.**

There are interesting reasons why many cities have been Badger-equipped. Let us tell them to you — show you what Badger Meters will do on your lines.

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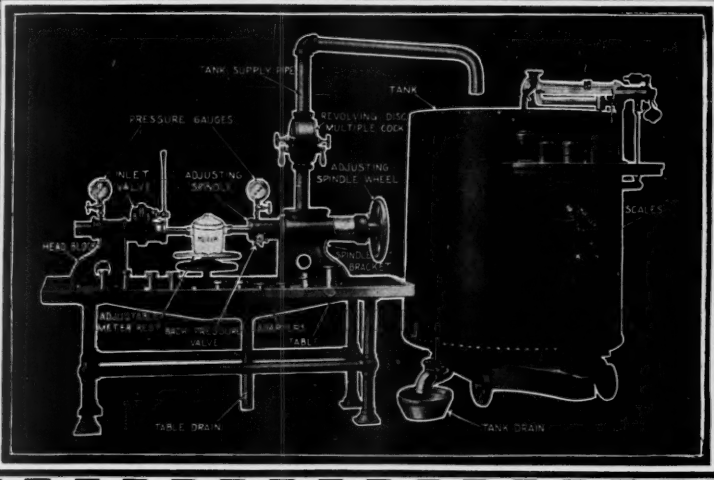

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Mueller Water Meter Tester

The Mueller will prove exactly what each meter does—will enable you to adjust each meter to absolute accuracy—will save more than its cost year after year. Used and endorsed by leading municipalities. The name Mueller guarantees both Quality and Service.

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First. — We make a specialty of furnishing Complete Water-Works Pumping Units of all types.

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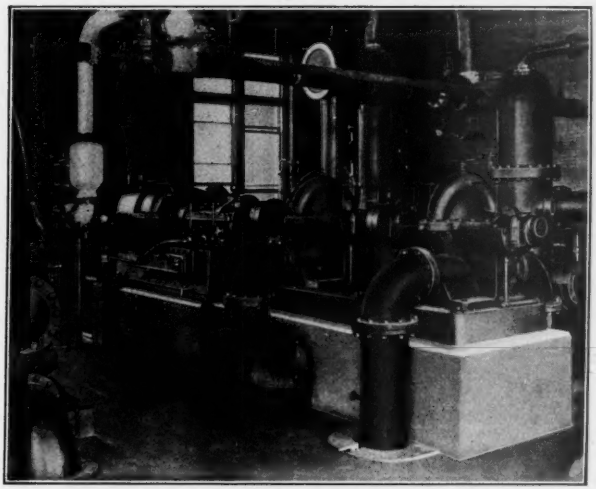
Fourth. — Every unit installed to date has exceeded its guarantee and has been completely accepted.



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F. A. Mazzur & Co.

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IF CURRENT GOES OUT
STEAM NOT AVAILABLE
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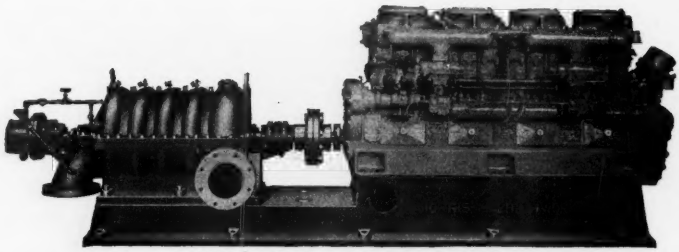
Often Installed, Never Fails, and Always Ready.



Morris 8″ Five Stage Pump and 300 HP Eight Cylinder Engine, to deliver 1400 GPM against 300 Ft. Head.

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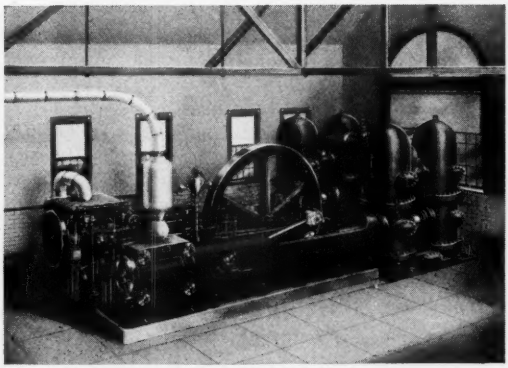

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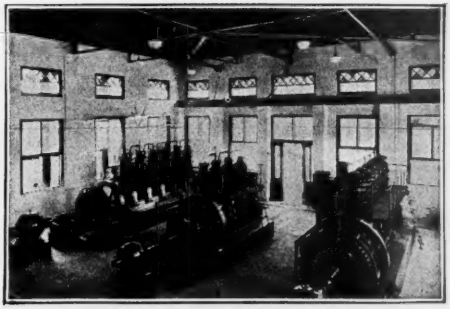

Low cost power for municipal plants

The following cities were among those installing F-M equipment during the past year:

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Onset, Mass.
Wareham, Mass.
Brant Rock, Mass.
Cherry Valley, Mass.
Milford, N. H.
Beach Haven, N. J.
Millsboro, Del.
Middletown, Del.

Many municipal plants have discovered that their rates cannot keep up with the excessive operating costs of antiquated power units. And in Fairbanks-Morse Diesel Engine economy they have found a way to make profits where formerly they were losing money.

In a large number of plants, F-M Diesel units have been installed in conjunction with complete F-M pumping and power equipment, including F-M alternators, motors, pumps, and auxiliary equipment. Such an installation is represented by the pumping and lighting plant illustrated above. Here undivided responsibility rests with Fairbanks-Morse, and a definite guarantee insures economical and completely satisfactory service.

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Manufacturers of Oil Engines, Pumps and Electrical Machinery
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DIESEL ENGINES · PUMPS · MOTORS

Complete power and pumping F M *equipment for municipal plants*

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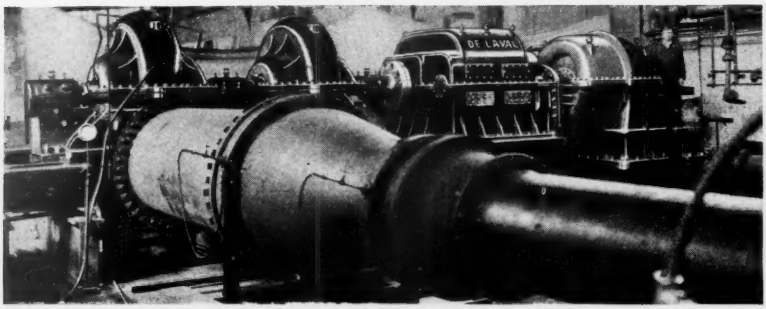
CENTRIFUGAL PUMPING EQUIPMENT

is the accepted standard for

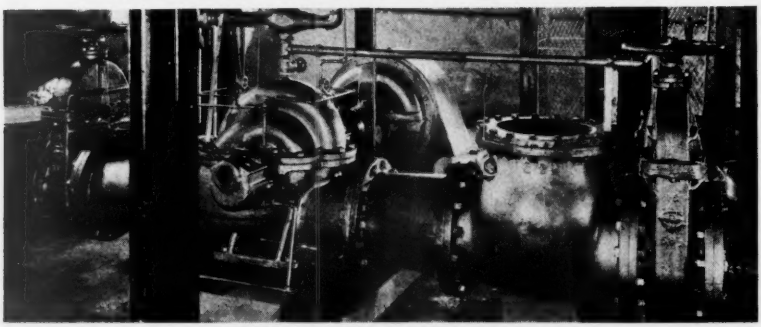
MUNICIPAL WATER WORKS



WESTERN AVENUE PUMPING STATION, CHICAGO.

The largest Municipal steam turbine driven centrifugal pumping unit in the world delivering 75 million gallons per day against 150 feet head.
City of Chicago has fourteen large DE LAVAL pumping units.

TYPICAL NEW ENGLAND INSTALLATION



MILLVALE STATION, HAVERHILL, MASS.

New 7 million DE LAVAL motor-driven pump including the furnishing and erection of transformers and switchboard equipment. On test after installation this pump delivered water at rate of 7,800,000 gallons per day. Another DE LAVAL unit is on order for Kenoza Station, Haverhill.

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Ask for De Laval Publication.

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NEW ENGLAND REPRESENTATIVE FOR

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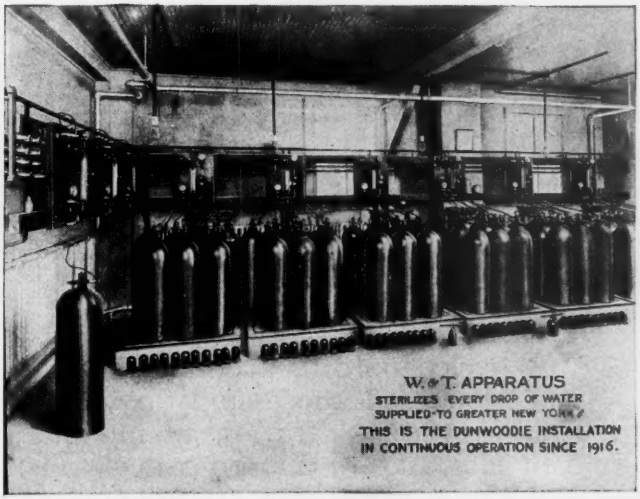
Chlorination Must Be Dependable!


W. & T. APPARATUS
STERILIZES EVERY DROP OF WATER
SUPPLIED TO GREATER NEW YORK
THIS IS THE DUNWOODIE INSTALLATION
IN CONTINUOUS OPERATION SINCE 1916.

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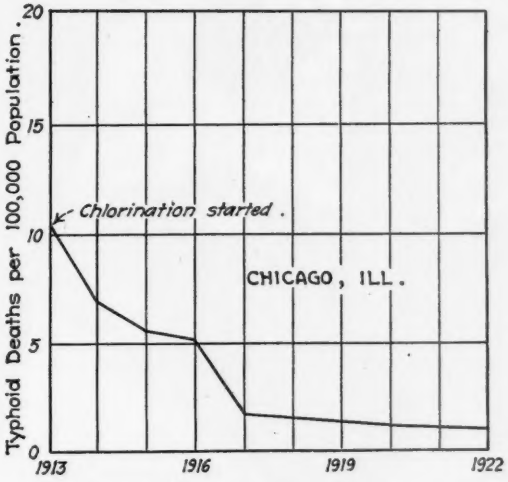

DIAGRAM SHOWS REDUCTION IN TYPHOID FEVER DEATH RATE AFTER INSTALLATION OF CHLORINE

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Sunk in the Battle of Sabine Pass

The funnel of the Union Gunboat Clifton still marks the spot, off the Texas Coast, where she went down under Confederate fire. For sixty years she has lain there, silently fighting the ever-present forces of corrosion, re-enforced by salt water and spray. But the stuff she is made of—genuine wrought iron—has withstood all these assaults. Not long ago, her walking beam, in a fine state of preservation, was recovered and mounted in Keith Park, at Beaumont.

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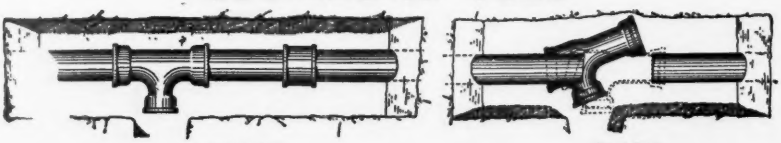
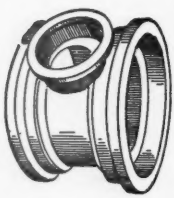


Old Way *Our Way*



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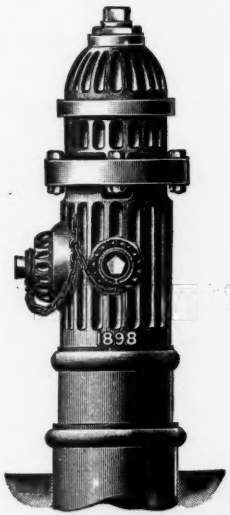

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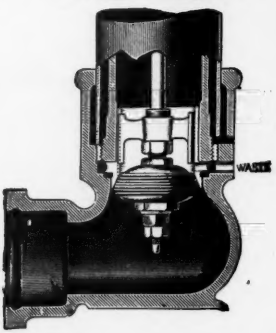
A half century of use has established their reputation as being the most economical, durable and simple hydrant.

Number in use exceeds total of all other makes combined.



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ANTI-FRICTION
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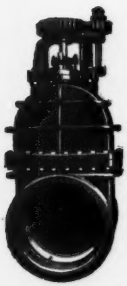
For Every Method of Operation



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There's a tested Kennedy design and arrangement for any type of valve control that may be required by your operating conditions. We can refer you to Kennedy Valves operated through spur or bevel gears, by hydraulic cylinders, by motor either directly or in connection with automatic distance control, and by hand operation through quick-operating levers, or extended stem with post.

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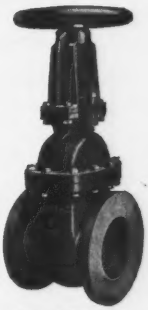

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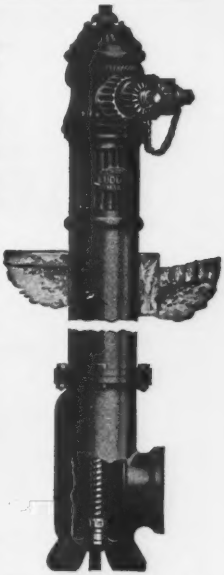

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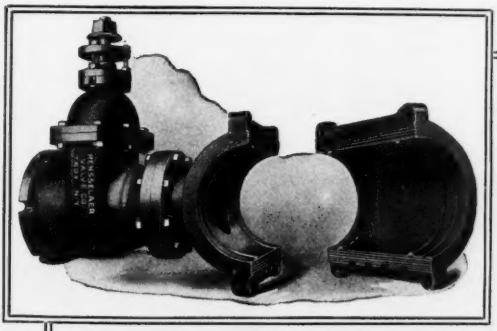

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They can be used with all standard makes of Tapping Machines.

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Have two lead rings.

Require less lead for calking.

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Bolting flanges are made full length of sleeve, giving great strength.

Have greater thickness of hubs on ends.

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Hydrant with Independent Nozzle Cut-off.

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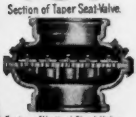


Section of Vertical Check-Valve.

Section of Vertical Foot-Valve.

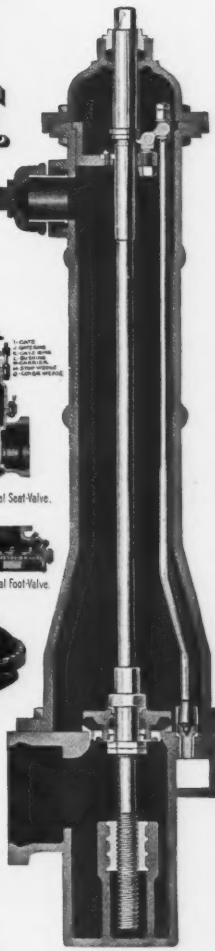
Horizontal Check-Valve.

Vertical Foot-Valve.

Hydrant with Water Crane Attachment.

Indicator Post.

Water Crane with Automatic Drip Valve.



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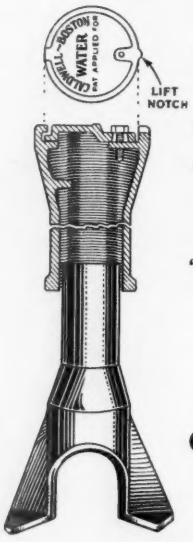
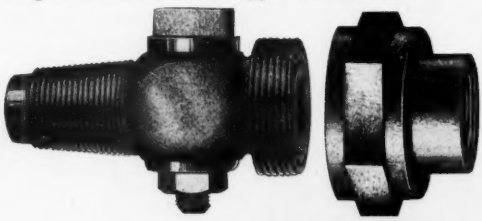
Top section is interchangeable with the "Slide Type" Buffalo Box



No change necessary in wrench or shut off keys



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Brass Goods, Curb and
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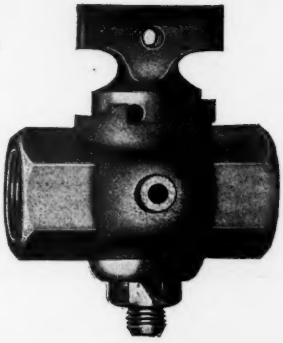

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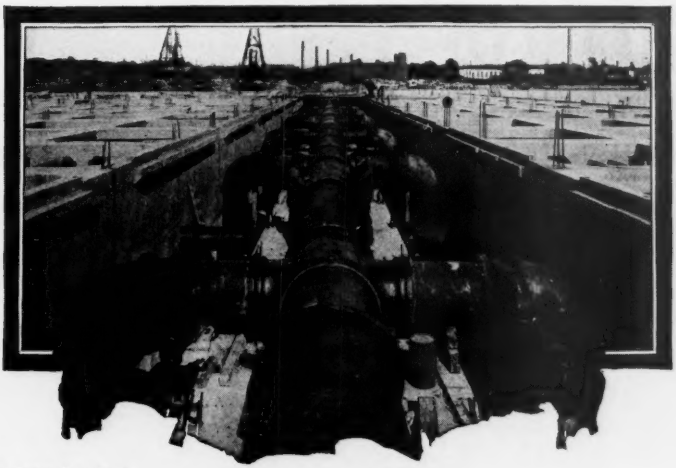

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Special Castings, Fire Hydrants, Valves

General Foundry and Machine Work

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NEW YORK CITY

HIGHEST AWARD, GOLD MEDAL,
ST. LOUIS EXPOSITION, 1904

Over 100 Water Departments

use

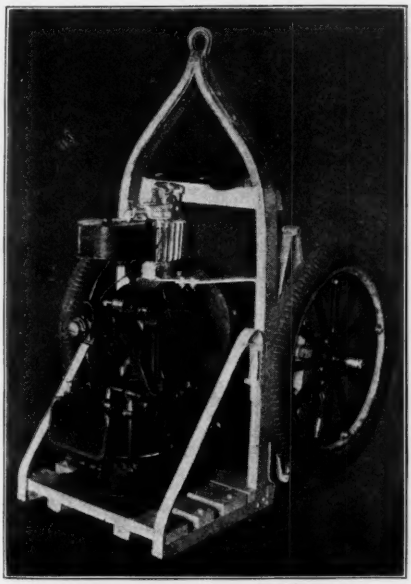
LEAD-LINED IRON and TIN-LINED PIPES

for their service connections

MANUFACTURED BY

Lead Lined Iron Pipe Company

Wakefield Mass.



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TRAILER
PUMP UNIT

— IS —

Light
Compact
Efficient

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EDSON
MFG. CORP.
375 BROADWAY
BOSTON

Warren Foundry and Pipe Co.

(Formerly Warren Foundry and Machine Co.)

SALES OFFICES
11 BROADWAY, NEW YORK
201 DEVONSHIRE ST., BOSTON, MASS.
Telephone, Fort Hill 5951

CAST IRON PIPE

Bell and Spigot Flanged Pipe
Special Castings
Flexible Joint Pipe Cylinders

Water Gas Sewers Culverts

Works, Phillipsburg, N. J.

LARGE STOCK ENABLES US TO MAKE QUICK SHIPMENTS

Twelve Reasons Why

YOU SHOULD USE

Trade "LEADITE" Mark

Registered U. S. Patent Office

FOR

Jointing Water Mains

1. **DURABILITY.** Leadite joints increase in strength with age.
2. **NO CAULKING.** Leadite joints require no caulking, because the Leadite adheres to the pipe, making a water-tight bond.
3. **COMPARATIVE QUANTITIES.** One ton of Leadite is equivalent to four tons of lead.
4. **LABOR SAVING.** Saves caulking charges and digging of large bell-holes, and reduces the cost of trench pumping to the minimum.
5. **COST.** Its use saves 50 to 65 per cent. over lead, owing to the saving effected in material and labor.
6. **TOOLS.** As no caulking is required, fewer tools are needed.
7. **TRANSPORTATION.** Considerable freight charges are saved because Leadite is lighter than lead.
8. **HAULING.** Saves hauling expense on the work because you move only one fourth the weight of jointing material.
9. **FUEL.** Saves fuel because you melt only one ton of material instead of four, and not as much heat is required either.
10. **DELIVERY.** We can make prompt shipments.
11. **DAMAGE SUITS.** Claims for damages caused by joints blowing out are prevented because Leadite joints will not blow out under any pressure.
12. **USERS.** Progressive water works all over the country use Leadite.

WRITE FOR BOOKLET

The LEADITE COMPANY, Inc.

Land Title Building **Philadelphia**

P. E. KELLY, New England Representative

8 TRENT STREET **ARLINGTON, MASS.**

Chadwick-Boston Lead Co.

162 Congress St., Boston

Agents for

The Celebrated "ULCO"

LEAD WOOL

(Every Atom Pure Lead)

For calking pipe joints under the most difficult conditions.

For overhead joints, or in wet places where the use of molten lead is not only impracticable but dangerous — **LEAD WOOL** may be used to advantage.

It makes an absolutely tight joint which will withstand the highest pressure, yet be sufficiently elastic to allow considerable sagging or settling of the pipe without danger of a leak.

As compared with the poured joint, in this respect, the superiority of **LEAD WOOL** is apparent.

Manufacturers of

Lead Pipe, Tin Lined Lead Pipe, Pure Block-Tin Pipe, Solder, White Lead and Red Lead.

HIGHEST QUALITY SOFT BRANDS

PIG LEAD

TEN CENTS PER POUND PRICE TEN CENTS PER POUND PRICE TEN CENTS PER POUND TEN CENTS

Join Your Water Mains

WITH

LEAD-HYDRO-TITE

TRADEMARK

AND CUT YOUR EXPENSES

50% FIRST COST

50% SMALLER BELL HOLES

75% HANDLING

100% CALKING

OUR PROPOSAL

That the prospective users purchase a trial lot of 1 to 5 bags, and that this be used under the direction and according to the instructions of our representative.

If, after a trial, the purchaser is not satisfied with the material, any surplus not used to be returned to the Hydraulic Development Company, and no charge to be made for any of the Hydro-Tite furnished.

Owned, Manufactured and Sold by New Englanders

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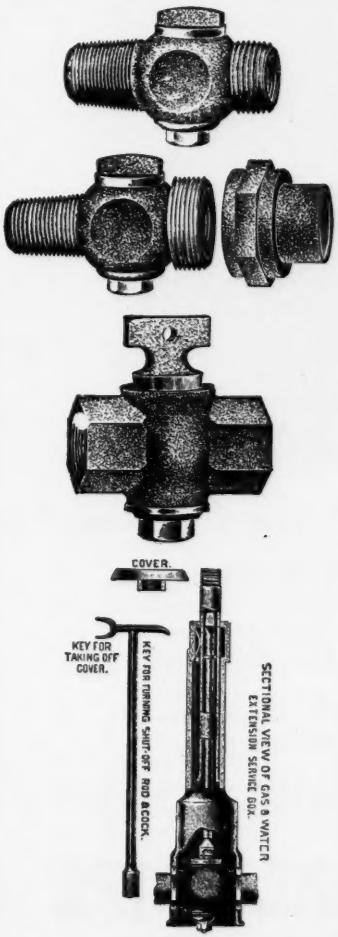
Hydraulic Development Company

296 BOYLSTON STREET

BOSTON, MASS.

TEN CENTS PER POUND PRICE TEN CENTS PER POUND PRICE TEN CENTS PER POUND TEN CENTS

"The Goods That Please"



Corporation and Curb Cocks

We have them to meet every requirement

ORIGINAL

"Hays-Erie"

Extension Service Boxes of proven advantages

Let us send at our risk, on 30 days' trial, a

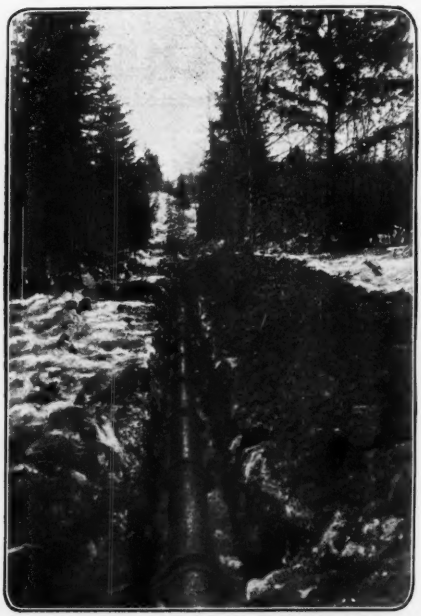
Payne's Patent Tapping Machine

which is recognized to be the most easily operated owing to the few working parts.

Hays Mfg. Co., ERIE PENNSYLVANIA

Established 1869

WATER SUPPLY AND FIRE PROTECTION LINES THAT *STAY* TIGHT



Contractors and Engineers:
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Laid in the dead of a New England Winter

DOVER-FOXCROFT WATER DISTRICT
DOVER-FOXCROFT, MAINE

24,000 feet of 10-inch Universal Cast Iron Pipe

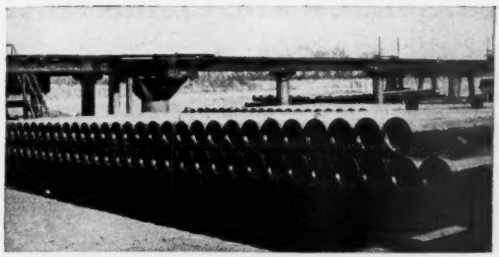
No bell holes to dig. No joints to calk.
Wrenches the only tools.

[For tight, flexible, dependable water supply and fire protection lines address nearest office]

UNIVERSAL CAST IRON PIPE

THE CENTRAL FOUNDRY COMPANY
Subsidiary of
The Universal Pipe and Radiator Company
41 East 42nd Street, New York

Sales Offices: *New York* *Chicago* *Birmingham* *Dallas* *San Francisco*

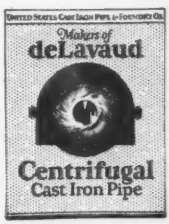


deLavaud Centrifugal Cast Iron Pipe

— is now ready to ship in sizes from 4" to 20"

The principal features of deLavaud Centrifugal Pipe are:

1 — Lower cost per foot.
2 — Greater carrying capacity due to larger inside diameter. Its smooth surface produces less friction.
3 — An even greater resistance to corrosion owing to its finer granular structure.
4 — Cheaper to install owing to its uniform lead space and self centering bell.
5 — It is easier to cut and tap.
6 — Its greater strength and uniform section makes it valuable for use for higher pressures.
7 — Adaptability to special joints due to its smooth exterior and uniform circumference.
8 — It is made to be used with standard fittings and specials.
9 — Annealing gives a uniform metal with no casting strains.
10 — This method of casting leaves no possibility for sand holes or gas pockets.



Write for special literature covering manufacturing conditions and specifications of deLavaud Centrifugal Pipe.

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General Offices:
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Philadelphia, Chicago, Birmingham, Buffalo, Cleveland, New York, San Francisco, Pittsburgh, Dallas, Kansas City, Minneapolis

STANDARDIZE ON THE CLARK METER BOX

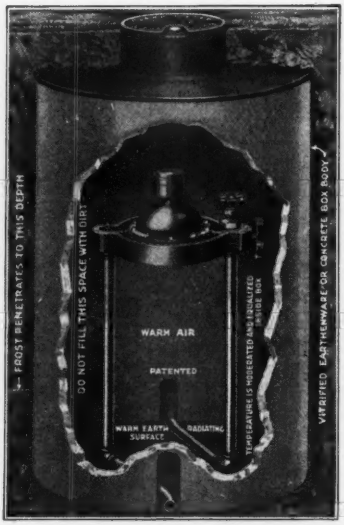
Houses all meters whether placed in boulevard, sidewalk or street in the same uniform and systematic manner and large meters as well as small ones.

A type and size to meet every climatic condition.

Why experiment when The Clark Meter Box has proven successful in thousands of Water Departments for over twenty years?

Perfect Locking Device

is operated by one third turn of key — It is always operative although not used for years. Due to the bronze construction of all working parts, it is not necessary to keep oiled. No guesswork as to the position of Lock, and no bothersome fumbling in getting box open. Operating Key is provided with double prong on handle for engagement into notched recess on lid for quick removal.



Meter Coupling Yoke

provides — Rigidity of supply pipes with meter in service or when removed; elimination of all strains and consequent leaks, with ample provision for expansion and contraction in pipe line. When control valve as illustrated is used curb cock and box may be eliminated — saving not only the cost thereof but pipe fittings and labor. Only four parts. Assembly is made without bolts, rivets or screws, and without aid of tools.

Protection from frost even at 60° below zero.

Send for catalog 24 — a treatise on modern water works practice

Meter Boxes	Meter Couplings	Repair Lids	Valve Housings
Vitrified Box Bodies	Meter Coupling Yokes	Vise for Brass Pipe	Meter Testing Machines
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H. W. CLARK COMPANY

Manufacturers Water Works Equipment

MATTOON, ILLINOIS, U.S.A.

FLOWING!!!
FLOWING!!
FLOWING! or

FLOWING!!!
FLOWING!!!
FLOWING!!!

STAND beneath the brink of Niagara Falls. Watch the millions of gallons of water flowing, flowing, day and night, year in and year out. The thought is almost appalling!

A city's water supply should be as ceaseless and unfailing. It should be permanently available in undiminished quantity.

But how can you get it? Not with a pipe with a rough interior. Not with a pipe that loses its carrying capacity through tuberculation. Not with a pipe with excessive leakage. Not with a pipe with a short life.

But you can get it with Lock Joint Reinforced Concrete Pipe which has:

Permanently strong walls
Permanently smooth surfaces (non-tuberculating)
Permanently tight flexible joints
Permanency of life.

PRESSURE
SEWER
SUBAQUEOUS

LOCK JOINT
Reinforced
Concrete Pipe

Lock Joint
Pipe Company
Rutledge Ave.,
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COPPER or BRASS

the best possible installation

for Service Pipe

These metals are best because they do not rust or become rust-clogged. They have long life and eliminate replacement and repaving expense. The most economical installation is possible through the use of COPPER or BRASS.

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25 Broadway – New York

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New England Water Works Association.

ORGANIZED JUNE 12, 1882.

APPLICATION FOR MEMBERSHIP.

.....
Full Christian name and surname

residing at.....
(City or Town and State)

desiring to be admitted to Grade of.....
(Junior, Member, Corporate or Associate)

membership in the New England Water Works Association submits the following statement:

I was born at.....
(Place of birth)

.....
(Date of birth)

Have been engaged in the following named work:

.....

.....

.....

.....

.....
(Finally state present occupation)

I will conform to the requirements of membership if elected:

Signed,.....

Address,.....

Dated.....*192* .

FEES AND DUES

Entrance Fees:				Annual Dues:			
Members	$3.00	Associates	$10.00	Members	$6.00	Associates	$20.00
Juniors	1.00	Corporate Members	10.00	Juniors	3.00	Corporate Members	10.00

Endorsed by.....

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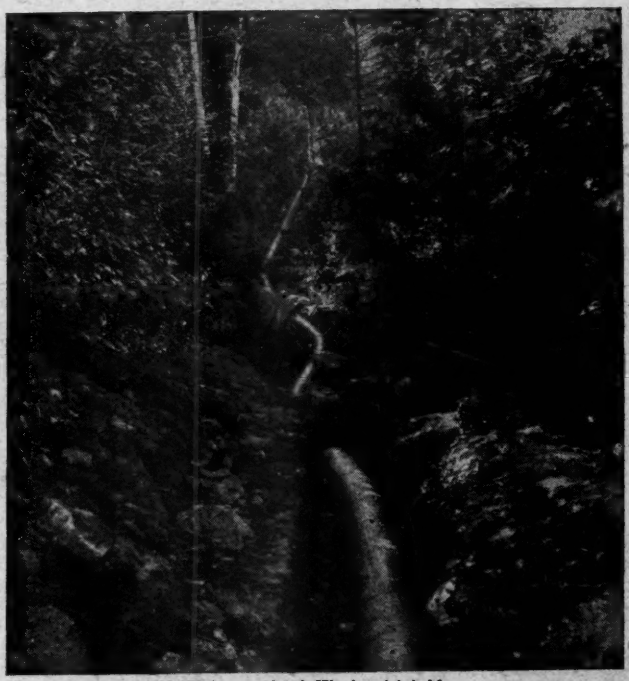

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